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ABSTRACT

Prepared in accordance with the Marine Resources and Engineering Development Act of 1966, this annual report reviews the nation's efforts to comprehend, conserve, and use the sea. Protecting and enhancing the marine environment together with developing and managing marine resources are emphasized. It includes: (1) a comprehensive description of the activities and accomplishments of all agencies and departments in the field of marine sciences during fiscal year 1971, (2) an evaluation of these activities, (3) recommendations for legislation, and (4) an estimate of the funding requirements of each agency and department for marine science activities for the succeeding fiscal year. Based on the major purposes of the Federal Marine Science Program, it summarizes the many facets of international cooperation and collaboration, national security, fishery development and sea food technology, transportation, development and conservation of the coastal zone, health, nonliving resources, oceanographic research, education, environmental observation and prediction, ocean exploration/mapping/charting and geodesy, general-purpose ocean engineering, and national data centers. Numerous charts and photographs are dispersed throughout the text, with statistical data and supplemental information provided in the appendix. (BL)

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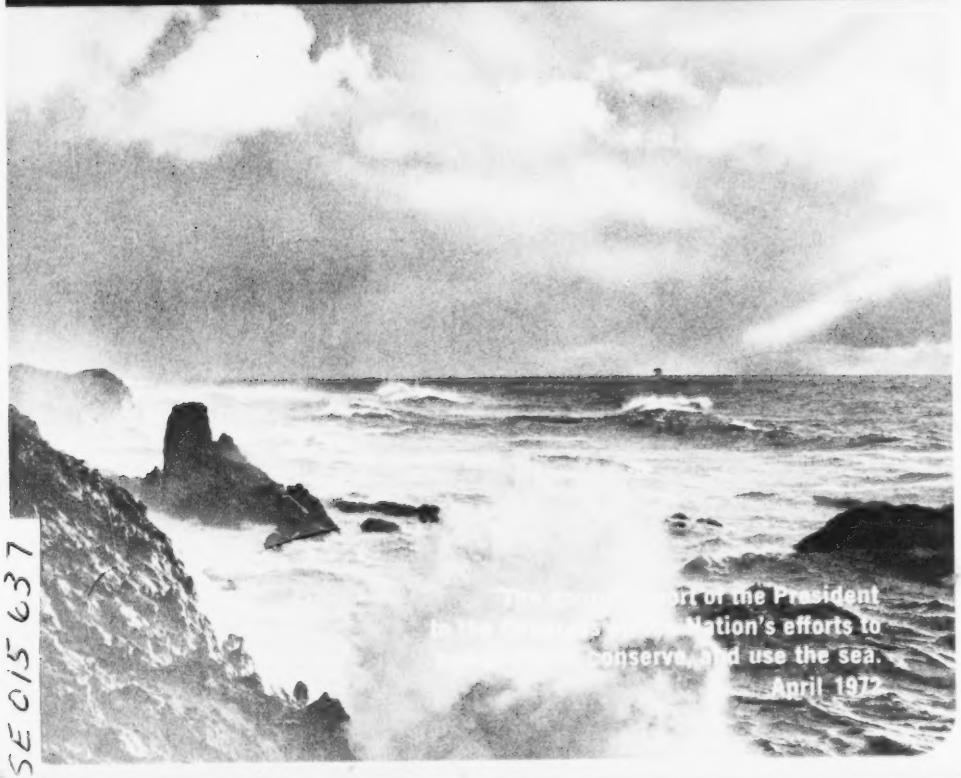
THE FEDERAL OCEAN PROGRAM



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THE FEDERAL OCEAN PROGRAM

The annual report of the President
to the Congress on the Nation's efforts to
comprehend, conserve, and use the sea.

April 1972

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PRESIDENT'S TRANSMITTAL MESSAGE TO CONGRESS

TO THE CONGRESS OF THE UNITED STATES:

It is with pleasure that I transmit today the report of the Federal Ocean Program. It has been a year of significant accomplishments and continued evolution of new directions to know, conserve, and use the sea.

A most important characteristic of our maturing ocean program is that we are increasingly viewing our efforts in the marine environment from the fresh perspectives illuminated by our need for its abundant resources and by the necessity to search carefully into the consequences of our actions in its development. We must insure the proper balance of these through measures which are compatible with the long-term maintenance of a healthy marine environment.

During 1971, strong emphasis was placed on improvements in the management of our marine living and nonliving resources, on easing pressures which threaten certain species with extinction, and on enforcement of measures to prevent environmental pollution and degradation. We have stepped up our studies of the ways in which we must manage our coastal zones to protect our fisheries, to make them available for marine transportation, to minimize pollution, and to enhance their recreational values. I have recommended legislation to establish national land use policy programs which include priority provisions for coastal zone management.

Further, in view of our increasing concern with energy supplies to sustain the Nation's economic growth and the health and well-being of our people, the Federal Ocean Program moved to explore the geophysical and geological character of our continental shelves. It should be recorded that 1971 was the year in which the Federal Government began to move vigorously to map and chart these promising submerged lands and their resource potential.

A major share of the Federal Ocean Program continued to support vital national defense objectives related to operations in the marine environment. Nevertheless, the major program increases of the past few years and those for the coming year are in the civil sector. Among the important accomplishments have been the increasing momentum to provide the operational capability for man to do useful work beneath the sea through application of research submersibles and laboratory habitats; the development of a system for the assessment of the abundance and distribution of harvestable living marine resources; and the designation of the first four Sea Grant Colleges.

Our efforts to explore the marine environment have been increasingly characterized by the trend toward major large-scale studies conducted by

Federal agencies in national programs such as the Marine Ecosystems Analysis study of the New York Bight, and with other nations in international programs, such as the International Field Year for the Great Lakes and the International Decade of Ocean Exploration. In these, we are moving out to the ocean "laboratories" with arrays of ships, specially designed buoys, aircraft, earth-orbiting satellites, and submersibles to apply collective efforts to solve special problems and to advance knowledge and understanding.

I am pleased to report, also, the continued strengthening of Federal ties, both in scope and level of activity, with industry, state and local governments, and universities. I consider this a most essential aspect underlying our marine programs. As I have stated in the past, private industry, state and local governments, scientific and other institutions must increase their own efforts if we are to continue our headway toward solving the myriad of marine problems.

My budget request for the Fiscal Year 1973 provides $672 million in support of our programs in marine science, engineering, and services, an increase of more than $60 million over last year's request. This budget will enable us to continue our advances in all areas of importance to our vital and increasing national interests in the seas.

PREFACE

A Report to the President From the Office of Science and Technology, April 1972

THIS REPORT TO THE PRESIDENT ON THE FEDERAL OCEAN PROGRAM is prepared in accordance with Public Law 89–454, the Marine Resources and Engineering Development Act of 1966, which states that the President shall transmit to the Congress an annual report including: (a) A comprehensive description of the activities and the accomplishments of all the agencies and departments of the United States in the field of marine sciences during the preceding fiscal year; (b) an evaluation of such activities in terms of the objectives set forth pursuant to Public Law 89–454; (c) such recommendations for legislation as the President may consider necessary or desirable for the attainment of the objectives of Public Law 89–454; and (d) an estimate of funding requirements of each agency and department of the Federal Government for marine science activities during the succeeding fiscal year.

This report on the Federal Ocean Program is submitted to the Congress in response to that requirement.

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Chapter I

A NEW EMPHASIS

The decade of the 1960's saw a Federal Ocean Program born, given direction, and set in motion toward solving the problems and exploring the unknowns which tie man to the global ocean and to its rich and varied life forms. Now, two years into the decade of the 1970's, we find this national oceanic effort confronted by certain specific and pressing concerns which link human life and the natural world. A new emphasis pervades the record of Federal activities related to marine resources, environment, and ocean-looking science and technology—an emphasis that balances environmental imperatives with our demand for development in the marine environment.

This concern with the quality of life and environment necessarily influences the ways in which America approaches the marine science goals set forth in the Marine Resources and Engineering Development Act of 1966. Our ocean effort has become one in which development and conservation are balanced for the national benefit. The concept of a fragile natural world has become a major element among our conceptions of the sea and its resources.

The 1970's will be the decade in which we test how well we can resolve our differences with nature while still enjoying its bounty of resources. With an increasingly informed view of the consequences which follow human action, the Federal Government has moved in the past several years to meet the crucial need for a balanced approach to our physical environment—its resources and its life. The creation in 1970 of the Council on Environmental Quality, the Environmental Protection Agency (EPA), and the U.S. Department of Commerce National Oceanic and Atmospheric Administration (NOAA) marked the necessary first steps. The year 1971 gave these new agencies and their partners* in the Federal Ocean Program increasing opportunities to turn elements of national necessity into projects, hardware, and accomplishments. The President's budget for Fiscal Year 1973 provides funds that amplify these opportunities, particularly in terms of the new emphasis.

*The Departments of Commerce, Defense, Health, Education, and Welfare, the Interior, State, and Transportation; the Atomic Energy Commission; National Aeronautics and Space Administration; National Science Foundation; and Smithsonian Institution.

The dramatic confrontation of land and ocean along the rugged coast of Oregon suggests the challenge, problems, and opportunities of the Nation's effort to comprehend, conserve, and use the sea.

Resources and Environment

A compelling force in the Federal Ocean Program has been the growing awareness that the marine environment and its resources are linked in ways we do not fully understand. The Federal effort reflected this during 1971 as strong programs developed to improve our ability to manage and conserve the living resources of the sea, to tap nonliving resources without ecological penalties, to comprehend natural phenomena and their interaction with man's activities, and to end or mitigate what we have been doing wrong. At the same time, the Nation's impending energy crisis raised hard questions related to management and allocation of offshore resources.

An example of how such intersecting problems are affected by present stress on the environment is seen in the President's Energy Message of June 4, 1971, which recommended the acceleration of the sale of oil and gas leases on the Outer Continental Shelf, while insisting on the most stringent environmental protection measures possible. Such protection, in turn, requires the knowledge provided by extensive biological, geological, and geophysical research and reconnaissance surveys of these regions. This attempt to achieve equilibrium between developing a resource and protecting life and environment is characteristic of such Federal programs as they are now constituted.

Much effort continued to be applied during 1971 to the perennial difficulties of our fishing industry which, year in, year out, flourishes in a few sectors but languishes in many more. Here, as elsewhere, there was fresh emphasis on effective resource management, including international negotiations bearing on the impact of foreign fishing fleets, and on such programs as MARMAP (Marine Resources Monitoring, Assessment, and Prediction)—an initiative of NOAA which seeks to define the living resources of the oceans and guide their efficient management.

Although the discovery of mercury contamination in certain fishery products depressed the fishing industry somewhat in the early months of 1971, the overall effect was one of creating better awareness of potential problems requiring attention. A program of contaminant research and inspection by Food and Drug Administration (FDA) and NOAA laboratories concluded, after extensive sampling of fish stocks, that only in limited cases was a public warning necessary against particular items (e.g., swordfish) because of the incidence of contamination. As the year ended, the fishing industry had instituted quality control measures to police itself. The FDA-NOAA contaminant study continues, however, to insure timely detection of any future fishery-product contamination by mercury or other heavy metals and to track the flow of these materials from manmade and natural sources through the food chains of the sea.

Growing numbers of sport fishermen account for a large portion of this country's catch of saltwater fish and have a substantial impact on the economy in many coastal areas. It is estimated that some 9.5 million saltwater anglers made recreational fishing a $1.4 billion business in 1970. The Federal view of commercial fishing and sport fishing has increasingly become one of a single, collective living resource, with advantages to all constituents.

The Turn Toward the Coast

Americans are turning toward the coasts. The 1970 census showed that nearly 170 million Americans (about 83 percent of our people) live in our coastal States, and the population trend is increasing in this direction. Many of the environmental and resources problems facing the Nation flow from this concentration. Demands for work, housing, power, transportation, recreation, and other human activities proliferate in the coastal zone. Pollutants and wastes from these activities threaten valuable areas and natural resources.

New emphasis must be given to management of our lands and waters, a program which was proposed by the President in the National Land Use Policy legislation introduced in Congress and pending at the close of 1971. But to make that or any other land and water use management program effective, the problems of the coastal zone have to be clearly defined.

The greatest knowledge requirement is to quantify what thus far has been a virtual abstraction—that is, to be able to say that action A will be followed by consequence B, penalty C, benefit D, and so forth. Much of the Federal effort related to coastal zone activities has this as a short-term goal. All Federal programs share the longer range goal of intelligent combination of use and preservation of this national resource and its life forms. It is an effort that has barely begun and which has far to go.

In 1971, the Federal Ocean Program moved forward in estuarine modeling to simulate environmental conditions and processes; studies of specific estuaries, including Chesapeake, Delaware, Galveston, and San Francisco Bays; environmental impact studies of fossil-fuel and nuclear reactor powerplant siting; studies aimed at defining legal problems in the coastal zone; investigations of pollution abatement and control to improve criteria and standards of water quality, to prevent or contain oil spills, and to enforce water quality laws and regulations; and studies of relations between living and nonliving resources.

Internationally, the United States ratified the 1969 Inter-Governmental Maritime Consultative Organization (IMCO) convention governing intervention by a coastal nation in case of oil pollution casualties such as resulted from the *Torrey Canyon* breakup and ratified the 1969 amendments to the 1954 IMCO Oil Pollution Convention. Negotiations were completed on an international convention on the establishment of an international compensation fund to pay for the damages and costs of cleanup of oil spills. The United States also proposed a draft international convention to regulate ocean dumping. A United States-Canada ministerial meeting on Great Lakes pollution in June 1971 resulted in a decision to work toward common water quality objectives; a formal agreement between the two countries was signed by President Nixon and Prime Minister Trudeau on April 15, 1972.

Monitoring, Predicting, and Mapping

Whether using the oceans as a highway, a laboratory, or as fishing grounds, the describing and predicting of conditions in and above them are essential to their safe use. Marine weather and climate, sea conditions, navigable

waters and navigation hazards, shore boundaries, the contours and content of the Continental Shelf—all of these must be known. The Federal Ocean Program in 1971 took considerable strides toward descriptions of greater detail, predictions of longer duration and greater accuracy, and new information management techniques to handle vast bodies of data. The emphasis in marine environmental monitoring and prediction services has been to improve present services and to develop a system capable of monitoring natural and man-induced phenomena, including physical, chemical, biological, and certain geological characteristics in oceanic and coastal regions.

Progress was made during 1971 in the development of the satellite and the ocean data buoy as key technological elements for acquiring observations of the ocean and atmosphere. The year 1972 will see the development of both buoys and satellites that will enable us to test the expectations of revolutionary new methods for monitoring the global ocean. A test buoy system will be deployed in the Gulf of Mexico and infrared-sensing satellites will provide a uniquely thorough look at sea-surface temperatures.

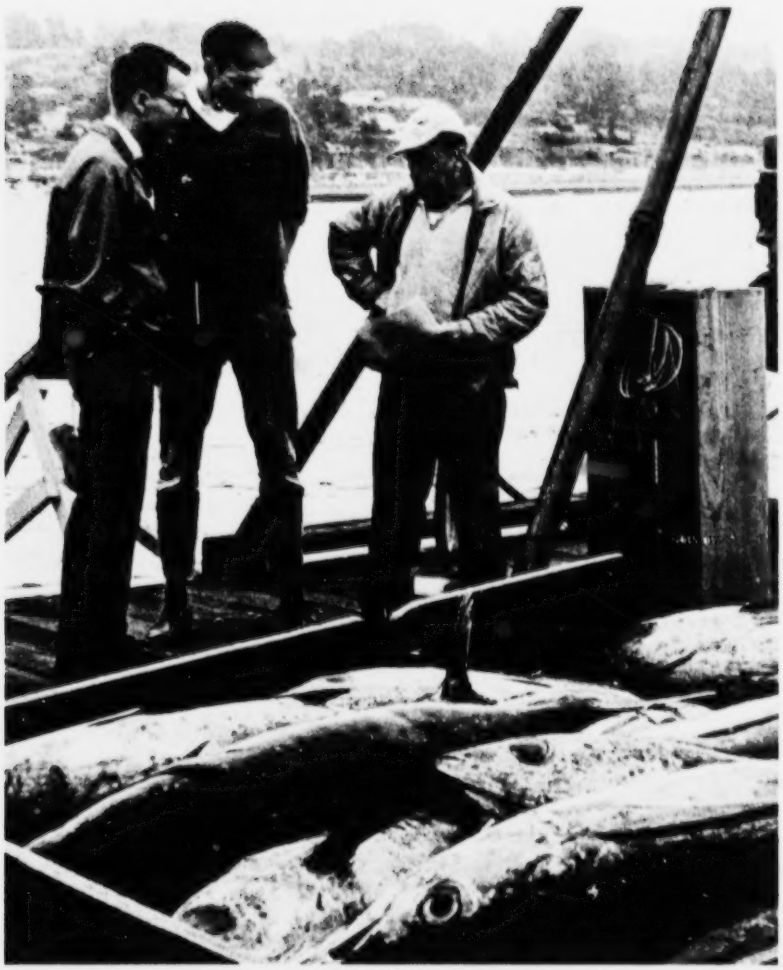
Impelled by the national need to tap new offshore reserves, particularly oil and gas reserves, the Federal Government began the systematic mapping of the Continental Shelf, its bathymetry, geophysical fields, and hidden resources. This expansion of marine geophysical and geological surveys is being carried out jointly by the U.S. Geological Survey (USGS) and NOAA. At the same time, Federal agencies sought to improve their cartographic descriptions of wetlands and seaward boundaries, to automate certain hydrographic and cartographic processes, and to extend geodetic control to offshore areas.

Ocean information services improved during 1971 as data management activities prepared for the major area studies planned for the 1970's and moved to increasingly automated information-handling systems. Services supporting oceanographic instrumentation were upgraded with new equipment, and two new facilities at Bay St. Louis, Miss., and Seattle, Wash., were being readied as regional calibration centers.

Marine Science and Technology

Significant progress was made in 1971 toward improving the Nation's ability to explore, inhabit, manage, and farm the sea. For Sea Grant, a notably successful marine sciences program begun in 1966, the year marked the beginning of a new phase. The first four Sea Grant Colleges—the University of Washington, Oregon State University, Texas A&M University, and the University of Rhode Island—were designated by the Secretary of Commerce, thus realizing one of the original intents of the Sea Grant College and Program Act. Other Sea Grant achievements for the year included establishment of extension advisory services and continued progress in mariculture, ocean engineering, resource management, and other areas of marine science investigation.

The civil manned undersea science and technology program began a promising series of basic and applied science projects using undersea habitats and research submersibles. Last year's projects included investigations of



As part of the national Sea Grant extension advisory service, agents from Oregon State University (left) talk with an albacore tuna fisherman as his catch is unloaded in Newport, Oregon.

the New York Bight, fisheries resources off Maine, and a variety of studies off Florida.

Major regional and international research projects continued to play a significant role in the Federal marine sciences effort. During 1971, pilot work began in an Arctic ice dynamics experiment, planning continued for several international investigations of the tropical ocean and atmosphere, an intensive study of Lake Ontario moved into its field phase, and a research investigation of the living resources of the Canary Current was being readied for the eastern central Atlantic. Continuing cooperative investigations included explorations of the Caribbean, Atlantic, Gulf of Mexico, and North

Pacific. The highly successful deep-sea drilling expeditions of the *Glomar Challenger* continued their important contributions to modern scientific theory concerning physical process in the earth's crust, such as continental drift.

The Nation's shipyards, shipping companies, and other segments of the maritime industry responded strongly and positively to enactment of the Merchant Marine Act of 1970. Construction subsidies required by shipyards were reduced more than 10 percent, and American merchant fleet modernization proceeded apace, particularly in terms of converting break-bulk ships into containerized cargo carriers. Shipyard backlogs of commercial tonnage at year's end were the largest since the beginning of 1958. Associated research and development programs investigated shipyard automation, propulsion systems, shipsized cryogenic tanking, offshore terminals, navigation and traffic systems, and prevention and mitigation of pollution by ships.

National Security

The largest single agency expenditure in the Federal Ocean Program continues to be that of the U.S. Navy and other agencies of the Department of Defense. Much of the work reported for 1971 concerned sustaining and improving the Navy's ability to operate on, under, and over the global ocean, and associated ocean services. Despite the largely operational character of the Navy's program, many of its research and development products found their way into the civil sector as the flow from military to civilian application accelerated.

Projects aimed at developing deep ocean power sources, new materials technology, deep-submergence vehicle research and development, studies of acoustic energy transmission underwater, advanced imaging systems, and underwater construction techniques are among the reported items with eventual civil impact. During 1971, a new automated oceanographic data-acquisition system became operational; the Navy accepted the first Deep Submergence Rescue Vehicle, DSRV–1, now planned for certification to 5,000 feet; and an automated shipboard forecasting system was installed aboard some Navy ships to provide onsite environmental predictions tailored to the requirements of specific weapons systems. Plans were underway to move selected Navy mapping and charting operations into the newly established Defense Mapping Agency, probably in mid-1972.

States and Nations

The Federal Ocean Program is politically bounded on one side by the rights of coastal States and on the other by the international character of the marine environment. Since 1966, the United States has sought to forge strong cooperative bonds at all governmental levels, here and abroad.

Internally, the Nation is developing functional ties between State and regional centers of strength in the marine sciences and various Federal agencies engaged in the ocean program. The Office of Sea Grant in NOAA has been a principal agent of this development. NOAA's National Marine Fisheries Service has also been actively moving in 1971 into the early phases of

a systematic effort to strengthen Federal-State cooperation as it affects management of living resources. The National Science Foundation (NSF), through its ties with the academic community, continues to be a strong partner in such efforts.

Activities on the international scene during 1971 reflected the growing concern that pollution observed today off most nations' coasts could be the precursor of general, global pollution of the ocean. The United States is continuing its preparation for international conferences, such as the Stockholm, Sweden, United Nations Conference on the Human Environment in 1972 and the IMCO Conference on Marine Pollution in 1973. Also of great significance is the United Nations' Law of the Sea Conference scheduled for 1973 to clarify jurisdictional and other legal questions which profoundly affect the way we use and conserve the sea and its resources. The United States also continues to participate in fisheries commissions and various other international bodies and proceeds with several international scientific endeavors, in particular, the first projects under the International Decade of Ocean Exploration (IDOE) which got underway during 1971.

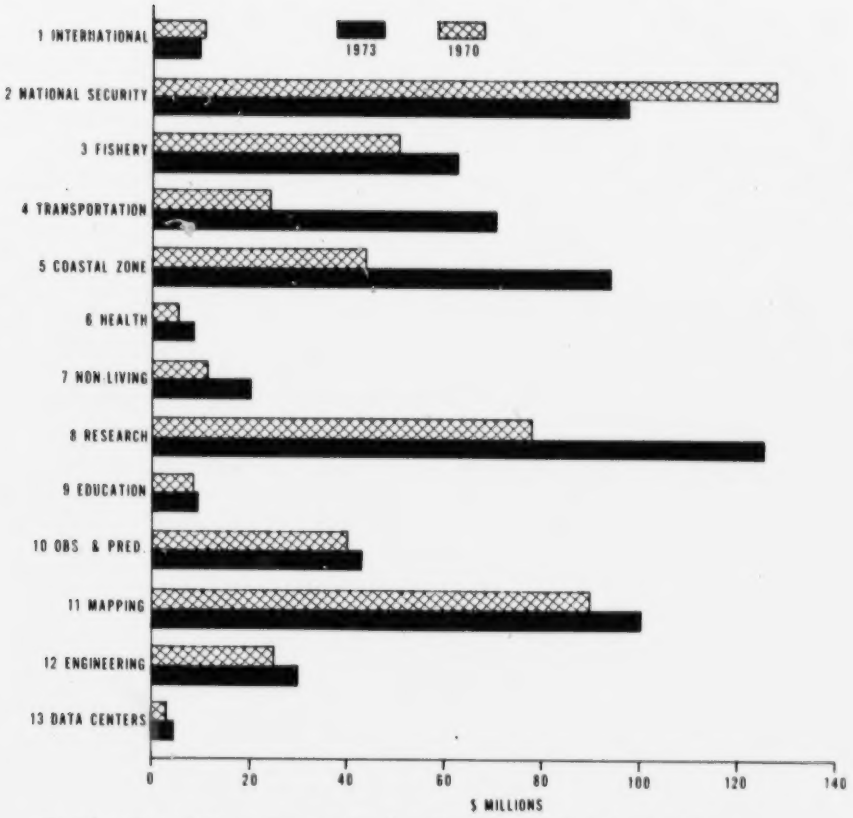
Institutional Adjustments

The year 1971 saw important institutional changes designed to make the Federal Ocean Program more effective. The National Council on Marine Resources and Engineering Development (the "Marine Sciences Council") terminated its activities. To undertake a continuing review and overall assessment of the progress of the Nation's marine and atmospheric activities as well as to advise the Secretary of Commerce on NOAA's programs and objectives, the National Advisory Committee on the Oceans and Atmosphere (NACOA) was established by the President in October 1971, pursuant to Public Law 92–125. NACOA, whose membership consists of 25 distinguished citizens knowledgeable in various aspects of marine and atmospheric science affairs, will submit its reports annually to the President and Congress through the Secretary of Commerce. It is anticipated that NACOA will provide invaluable assistance in the formulation of national program plans. (The NACOA charter and membership appear in appendix C.)

To meet the continuing need for interagency coordination of marine science activities at the policy level, the Chairman of the Federal Council for Science and Technology formed the Interagency Committee on Marine Science and Engineering (ICMSE) in mid-1971. Among its first-order considerations, ICMSE is examining Federal programs in coastal zone research and engineering, the multifaceted Chesapeake Bay area, and marine environmental quality. (The ICMSE charter and membership appear in appendix D.)

Other institutional changes during 1971 included:

—Establishment of the Office of Ocean Affairs (OOA) in the Department of Defense; headed by the Under Secretary of the Navy, OOA was responsible for preparing Department of Defense recommendations for the 1973 Law of the Sea Conference, ocean affairs policies, Department of Defense positions on international marine



Trends of Federal Ocean Program funding, Fiscal Year 1970 to Fiscal Year 1973.

affairs, and Defense representation on appropriate coordinating bodies. Its functions have recently been transferred to the International Security Affairs Office of the Secretary of Defense.

—Establishment of the Office of the Coordinator of Ocean Affairs (December 1970) in the Department of State to advise the Department on matters related to the formulation of U.S. policy in international ocean affairs, including organizational structures and U.S. participation in multilateral marine research programs.

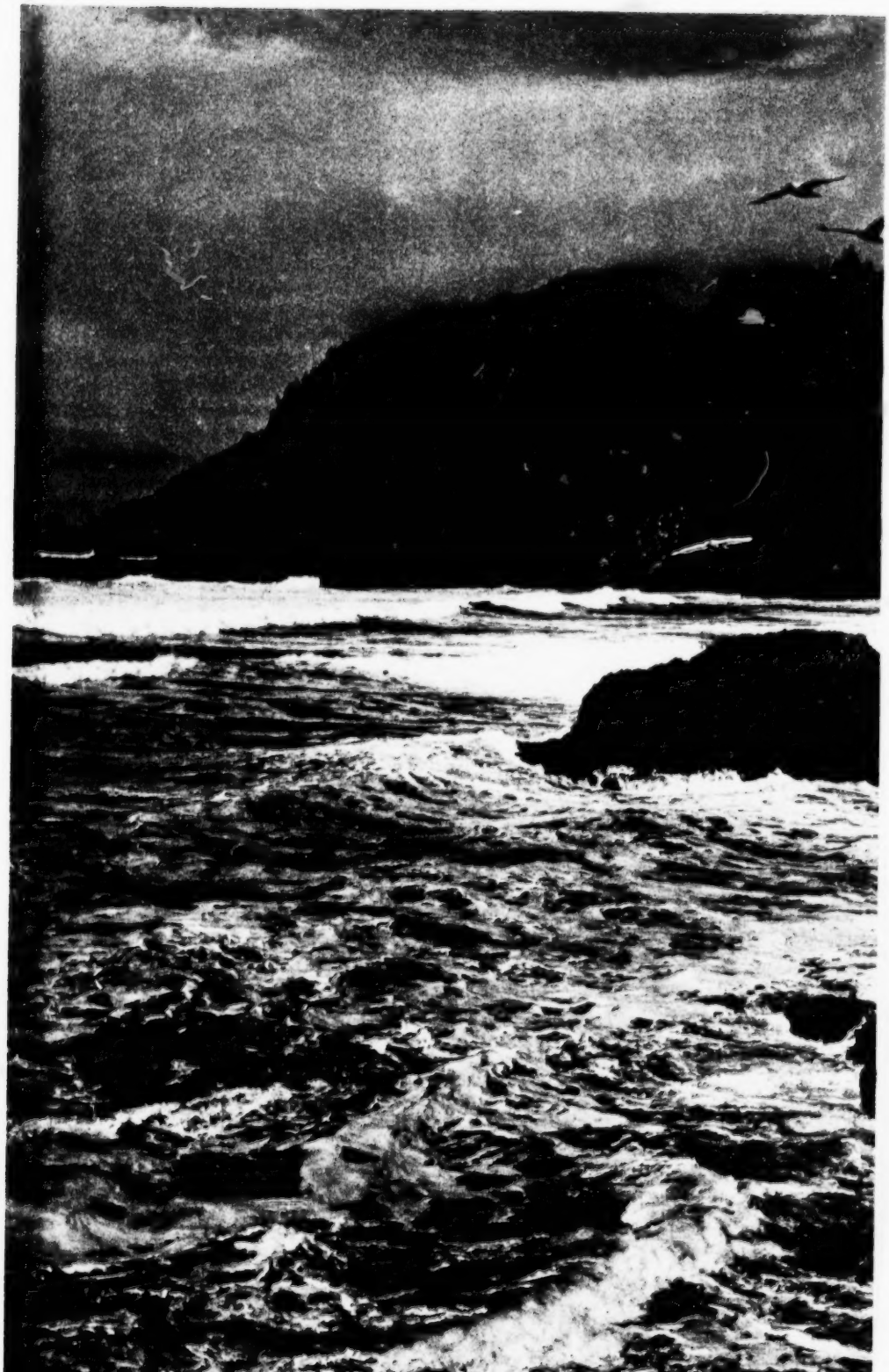
—Establishment of the University-National Oceanographic Laboratory System (UNOLS), by NSF and Navy to improve Federal academic utilization of marine research ships and shore facilities.

Level of Effort

Over the past 3 fiscal years, the configuration of funding for a Federal Ocean Program has been reshaped in significant ways by the emphasis on life and environment.

The proposed Fiscal Year 1973 budget of $672 million represents an increase of some $60 million over the Fiscal Year 1972 level of effort and of about $150 million over the Fiscal Year 1970 budget. The portion of Department of Defense effort reported under the category of national security, once the largest single item, ranks third in Fiscal Year 1973, down from $127 million in Fiscal Year 1970 to about $97 million in Fiscal Year 1973. On the other hand, there have been increases in each of the other areas of the Federal marine science activities with substantial gains over the 1970 program for transportation (195 percent), coastal zone development (115 percent), nonliving resources (90 percent), oceanographic research (66 percent), and fishery development (24 percent). The large increase in transportation last year and in the 1973 program comes from a major effort to strengthen the marine law enforcement activities of the U.S. Coast Guard, particularly as they bear on preventive and punitive actions related to marine environmental pollution and fisheries treaties.

Fiscal summaries are presented in appendix A, by agency and major purpose, in the format used in reports of previous years by the National Council on Marine Resources and Engineering Development. The scope of Federal marine science activities of the several agencies is summarized in appendix B.



Chapter II

PROTECTING AND ENHANCING THE MARINE ENVIRONMENT

Few issues have caught the national eye more powerfully in recent years than those of man and environment, and few issues have been brought to operating programs more swiftly by the Executive and the Congress. The necessity for the United States to achieve and enforce some kind of balance between taking and giving in the marine environment and coastal zone and to end destructive practices there has become a major force in the Federal Ocean Program.

Solutions to this set of difficult problems once seemed more straightforward than they appear today. For example, it is understood now that some types of environmental damage, once thought profound and permanent, are reversible, while other seemingly superficial changes produce lasting damage; much of the heavy impact of domestic and industrial wastes appears to be reversible through proper abatement programs, but a dredge-and-fill operation may cause permanent damage by substituting a new physical environment for what was there before. Consequently, the Federal Ocean Program has strengthened its efforts to define the severity and permanence of various chemical, physical, and biological alterations that degrade the marine environment and coastal lands. The program also seeks to comprehend and treat the marine environmental damage caused by natural forces—natural mass mortalities of fish and shellfish, blockage of estuaries by maritime storms, and drought-caused changes in estuaries and coastal currents.

The Federal approach to use and conservation of the marine environment takes many forms. In some cases, it builds upon locally supported programs and activities and supports research in universities, State agencies, and private industry. As a result of the President's Executive Order Number 11507 of 1970, pollution abatement programs at Federal installations are being aggressively pursued. Federal aid to municipalities helps them improve effluent treatment facilities, and Federal grants are made to develop local and regional marine management capabilities. The Congress continues its substantial interest in marine environmental problems. Both Congress and the Administration have taken initiatives in proposing legislation

"We should strive for an environment that not only sustains life but enriches life, harmonizing the works of man and nature for the greater good of all."—
RICHARD NIXON.

toward a national policy for management, beneficial use, protection, and development of the land and water resources of the coastal and estuarine zones.

Within Federal agencies, marine environmental programs reflect the areas of principal concern: the coastal zone, water quality, and recreation and international cooperation in solving on a global and regional scale the marine environmental problems which trouble us today.

The Coastal Zone

The consequences of our past and present marine environmental practices are most visible where civilization and the sea confront one another across a narrow band of shore and tidelands. The complex physical and biological processes at work there are understood only in a general way, and the legal institutions governing the uses of this region constitute a dense web of conflicting rights and confused priorities at every level of Government. A major direction taken by the Federal Ocean Program has been to define problems more clearly. Now, with some of them identified, scientists in Federal agencies and their colleagues in private institutions and industry are seeking specific solutions.

The University of Michigan, using a simulation technique called WALRUS (Water and Land Resource Use Simulation), is helping Government officials, scientists, and businessmen to anticipate the long-range effects of environmentally significant decisions. This Sea Grant-sponsored project allows participants to assume roles of local officials faced with responsibility for managing a sample body of water (in this case, Grand Traverse Bay in Lake Michigan). In a few hours, they can simulate the effects of decades of accumulating population growth, industrial development, and pollution problems. The WALRUS concept is expected to be a useful educational device for coastal community leaders.

Another Sea Grant-supported project is helping the Marine Resources Council of the Nassau-Suffolk Bicounty Regional Planning Board in New York to improve its resource management methods. The Center for the Environment and Man, under a contract with the Board, has identified the research needed to solve the most pressing marine resource problems facing Long Island and has proposed management guidelines for future Board actions.

A marine-resources decision model is being developed by an interdisciplinary team at the University of California at Santa Barbara to assist Santa Barbara County in the formulation of its Seacoast General Plan. The model now consists of land use, pollution, marine resources, cost/benefit, air pollution, and sewage treatment submodels. An initial enumeration of the many effects of various land uses on the different environments and the resultant economic impacts has been accomplished.

While much of the expertise in the field of ocean law has been concentrated on the problems related to the 1973 United Nations Conference on Law of the Sea, the many other legal problems associated with use of the coastal zone and marine resources have been receiving increasing emphasis. Schools of Law in universities in most of the coastal States have developed

both ocean law curriculums and research programs. Coastal zone management problems are emphasized in the Sea Grant-sponsored ocean law programs at the University of Miami, University of Oregon, University of North Carolina, Louisiana State University, and others. Studies at the University of Miami include legal regulations of shoreline development, coastal regional law for Florida, Florida's role in controlling the pollution of the sea by oil from ships, development of casebooks on ocean and coastal legal problems (including marine pollution), and a study of the development of a national posture with respect to the deep seabeds. The University of Maine's School of Law has described and analyzed in a four-volume report the laws and regulations affecting the utilization of Maine's marine resources.

Increasing interest in the development and use of coastal resources and environment has resulted in a series of studies to provide objective information on the economic implications of various activities there and to define their social implications. University researchers in Sea Grant programs are now heavily engaged in this field. For example, as part of an interdisciplinary study of the management of Puget Sound, the University of Washington completed a study of how the Sound's land and water uses are determined, with an eye to improving their administration.

Studies at the University of Wisconsin examined the impact of the St. Lawrence Seaway on the economy of the Great Lakes Region and the economic effects of extending the shipping season on the Seaway. Other studies at Wisconsin considered the relations of water quality to outdoor recreation and the socioeconomic significance of recreation activities in the marine environment. The University of Miami is identifying and determining the economic and environmental roles of human activity on the Miami River and around Biscayne Bay.

It has been recognized for some time that we will not take full advantage of our human resources to solve these problems until we bring about the direct and continuing interaction of natural and social scientists. Several new programs are accomplishing this now, including the Ocean Studies Program of the Woodrow Wilson International Center for Scholars in Washington, D.C., the Woods Hole Oceanographic Institution's program in Marine Policy and Ocean Management, and the Scripps Institution of Oceanography's Center for Marine Affairs. Specialized Sea Grant curriculums such as the University of Rhode Island's Master of Marine Affairs Program, the University of Miami's Ocean Law Program, and the University of Washington's Marine Technology Affairs Program are producing graduates with training in both marine sciences and legal and social sciences. This interdisciplinary background will enable these graduates to function much more capably in ocean management positions than those with conventional, single-discipline training.

The U.S. Army Corps of Engineers is reorienting and expanding the scope of its urban area studies to assist State and local agencies in relating water problems in flood control, water supply, and waste water management to such problems as neighborhood renewal and transportation. Feasibility studies of waste water management have been completed for Chicago, Cleveland, Detroit, San Francisco, and the Merrimack Basin. Follow-on

studies with EPA, HUD, and other agencies will develop alternatives for State and local authorities to minimize environmental effects in Puget Sound and in the Great Lakes.

Regional Studies

Where coastal ecology defines areas of study that cross political boundaries and require investigations of regional scope, the associated research projects are necessarily cooperative ones. Such regional programs have the objective of developing a marine data base which defines problems of navigation, water supply, waste disposal, fisheries, recreation, construction, and other marine activities in a way that is useful to environmental managers.

A study of the Chesapeake Bay and its tributaries is seeking to define the future impact of increasing population, industry, competing uses, and other factors; and to develop short- and long-range management plans. This investigation of America's largest estuary is being led by the Corps of Engineers in close cooperation with the Bay studies of the Chesapeake Research Consortium (Johns Hopkins University, the University of Maryland, the Smithsonian Institution, and the Virginia Institute of Marine Sciences), NOAA, USGS, National Aeronautics and Space Administration (NASA), and the Research Applied to National Needs (RANN) program of NSF.

Initial planning for this study was completed during 1971 and an interagency task force began compiling a comprehensive list of all Bay research undertaken, underway, and planned. A physical model of the Chesapeake Bay, and associated mathematical models, will be central features of this study.

Another program, the Marine Ecosystem Analysis (MESA) established within NOAA in 1971, will integrate and extend the agency's ability to describe, understand, and monitor the physical, chemical, and biological processes of marine environments; provide information and expertise required for effective management of marine areas and of their resources; and analyze the impact of natural or manmade alterations on marine ecosystems.

Regional projects are the major emphasis of MESA. Four coastal areas are being considered, either because the marine environment has already been seriously damaged or because it is threatened by projected use. In each area, NOAA will carry out the program with assistance from other Federal agencies, the States, universities, and industry.

MESA will also coordinate interdisciplinary studies to assess the potential impact of proposed major environmental alterations, such as offshore port terminals and marine mining operations, and the impact of such natural phenomena as droughts, hurricanes, and fish disease epidemics. The New York Bight Regional Project will get underway in Fiscal Year 1973 as will development of detailed plans for Puget Sound, Delaware Bay, and southeastern Florida.

Many problems and concerns of the San Francisco Bay Region differ markedly from those of the regions described above. Streams entering the Bay contain large volumes of sediments, minerals, and pollutants from a variety of activities, including mining. Intensive land-sea investigations of the Bay Region were initiated during late 1969 in a cooperative program

involving the USGS, the Department of Housing and Urban Development, the Corps of Engineers, and the Association of Bay Area Governments.

During 1971, a small-scale base map of the Region was completed and large-scale planning maps of the land areas compiled. Baseline information, including changes in the properties of bay-floor sediments that have been deposited since man entered the region, has been collected and plotted. In Fiscal Year 1973, this continuing effort will apply earth resources satellite technology to studies of sediment dispersal in the Bay area.

The International Field Year for the Great Lakes (IFYGL) is a comprehensive joint United States-Canada program of environmental and water resources research with Lake Ontario and the Ontario Basin chosen for field observation. IFYGL objectives and plans are described in chapter VI.

Water Quality

Marine environmental quality programs are directed toward three major objectives: The establishment of water quality criteria for acceptable levels of possible pollutants in each environmental system; the regulatory and enforcement measures to limit purposeful and accidental discharges into these systems; and the development of technology to prevent pollution and remove polluting substances. These are integral parts of the Water Quality Standards Program. The enforcement plans are supplemented by other regulatory measures such as the Refuse Act Permit Program and the National Oil and Hazardous Substances Pollution Contingency Plan. Current technology programs emphasize oil-pollution problems and shipboard waste treatment.

Improved Criteria and Standards

The determination of acceptable levels of possible pollutants requires a thorough knowledge of the characteristics of environmental systems as they relate to present and future water uses. Over 90 percent of all waters subject to Federally approved use classification are assigned to recreation or propagation of fish and wildlife. The information needed to assess possible pollutant effects is acquired through multidisciplinary research and environmental monitoring programs supported by a number of Federal agencies.

In 1971, NOAA, FDA, and EPA continued their wide-ranging studies of the distribution and fate of pollutants in the marine environment and their effects on marine organisms. The NOAA and FDA efforts have focused on heavy metals contamination, while the EPA effort has taken a broad look at waste and other pollutants.

Part of NOAA's program originated in the late 1940's as an investigation conducted for and funded by the Atomic Energy Commission (AEC). This work, carried out by what is now NOAA's laboratory at Beaufort, N.C., was concerned with tracing the radionuclides of manganese, iron, and zinc (abundant in fallout) through estuarine life forms and environment and back to man. Recent emphasis on heavy metals as an environmental pollutant has reinforced this program and added such metals as copper, nickel, and cobalt to its studies. A parallel contaminant program conducted by NOAA is concerned primarily with detection of mercury, lead, and cadmium

in fishery products and interacts closely with the continuing heavy metals program of FDA.

The EPA effort produced a comprehensive technical review and critical appraisal of present techniques of water quality modeling as applied to estuaries for pollution-control program planners and managers. Procedures were developed to predict concentrations of wastes from outfalls in coastal situations and also to assess the limitations and effects of such waste disposal in coastal shelf waters.

As part of EPA's toxicological effects studies, bioassays on shrimp were conducted to determine the rates of absorption and effects of polychlorobyphenyls (PCB) introduced in wastes, food, water, and sediments. Concentrations as low as 1 part per billion of PCBs were lethal to juvenile shrimp over a period of 1 month, and concentrations of 5 parts per billion were lethal in acute (short-term) tests. Other work sponsored by NSF, primarily through IDOE, (see chapter VI) has shown that PCBs have reached levels of physiological significance in many organisms of the North Atlantic.

In the Department of the Interior, USGS continued its collection and analyses of data on dynamic processes and water quality in 40 estuarine systems. The information derived from these studies is stored in the joint USGS/EPA STORET (storage and retrieval) data management system for use in local management decisions. The Department's Office of Water Resources Research initiated several new investigations in its program to determine the transport mechanisms and ecological effects of pollutants, including heat and excess nutrients.

The Corps of Engineers completed waste water studies for five metropolitan areas—Chicago, Ill., Cleveland, Ohio, Detroit, Mich., San Francisco, Calif., and the Merrimack Basin. Follow-on studies with the assistance of EPA and other agencies will develop alternative plans for efficient waste water management systems that will substantially improve the quality of the receiving waters and the environment in general.

The Coast Guard started pilot studies in 1971 directed toward determining the source and concentration of oily wastes on beaches. The first beach being examined is Golden Beach, midway between Miami and Fort Lauderdale, Fla. This effort will provide a comparison with the study performed 12 years earlier by the American Petroleum Institute. Studies of offshore concentrations of oily waste have also been initiated using specially developed nets towed from Coast Guard ocean station vessels in transit and on station.

In addition to these, substantial progress was made in regional cooperative programs, and financial support was provided to environmental quality studies by State governments under the NOAA-administered Federal Aid Program.

Regulatory Measures

Pursuant to the Water Quality Act of 1965, each State, after full public hearings, adopted water quality standards and submitted them to the Federal Government for approval. Once approved at the Federal level, water quality standards become enforceable by the State and by EPA. The enforcement procedures, however, are time consuming.

Tributaries pour their pollution into Cleveland's harbor and thence to Lake Erie (background).

Violations must be identified by surveillance. Then, conferences between the parties and public hearings are required before abatement orders are issued. Court action can be sought only if abatement orders are not complied with.

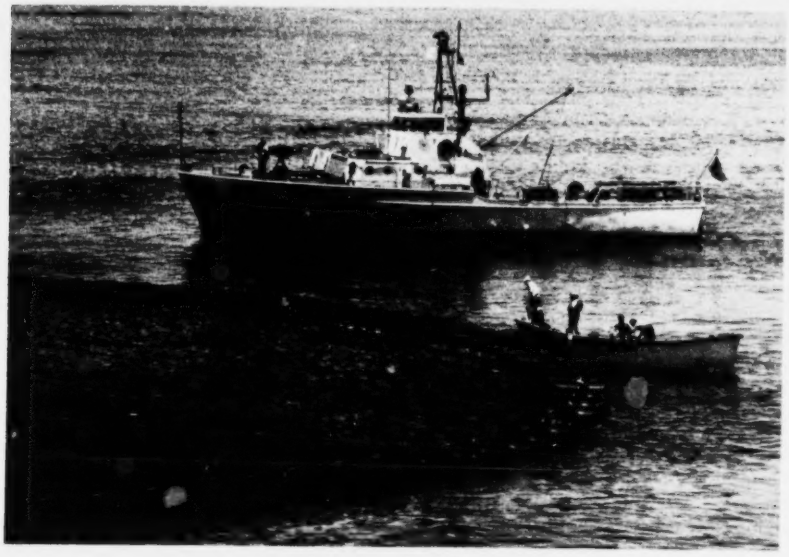
By contrast, the Rivers and Harbors Act of 1899 prohibits any discharge, other than liquid wastes from streets or sewers, into navigable waterways unless the discharger possesses a special permit. The applicability of this Act to pollution control efforts has been upheld by the U.S. Supreme Court, and, in 1971, it became the primary vehicle for enforcing water quality standards. Under the Act, dischargers are compelled to apply to the Army Corps of Engineers for permits. To obtain a permit, it is necessary to file a certification from the appropriate water pollution control agency that discharge operations will not violate water quality standards. Discharging refuse without a permit is a criminal offense. During Fiscal Year 1971, the Department of Justice filed 246 actions on violations of the 1899 Act.

The National Oil and Hazardous Substances Pollution Contingency Plan was developed in compliance with the Federal Water Pollution Control Act. The objectives of this plan are to minimize damage resulting from oil and hazardous substance discharge. Onsite coordination of containment or disposal operations in marine waters and the Great Lakes is provided by the Coast Guard. The USGS is responsible for supervising oil-drilling and production operations and pipeline transmissions. EPA coordinates

cleanup operations in inland waters. The Department of Defense provides assistance in critical spill situations, and NOAA provides scientific advisory services and environmental forecasts.

The Coast Guard uses aircraft as well as cutters in surveillance to detect discharges and spills of unknown origin. It is also determining the feasibility of remote-sensing techniques for detecting oil slicks. A national strike force is maintained with components on all coasts for deployment in cleanup operations, and a National Pollution Response Center has been established by the Coast Guard. The Center will house an information system to provide the on-scene coordinator with real-time information about local environmental and weather conditions, possible hazards resulting from the nature of the spilled substances, and other dangers that may be encountered in the operation. Most spills are of minor consequences, and the discharger acts to combat the spillage. In these cases, the on-scene coordinator provides advice, monitors the operation, and documents the case for possible enforcement action.

An estimated 50 spills requiring direct cleanup action by the Coast Guard occurred in 1971. In the 5-month period, July through November 1971, the Coast Guard reported 4,000 spills, 294 of which were knowing actions by dischargers and 37 of which were instances of failure to report a spill. In addition to these incidents, several oil-drilling rig fires occurred during the year, but the oil companies were able to control them and avoid apparent major damage to the environment.



As the Coast Guard Cutter Point Thatcher *stands by, marine engineers test an experimental floating oil barrier during a simulated oil spill. Soybean oil, which is nontoxic and biodegradable, is used in place of crude oil.*

Two Federal agencies are responsible for highly specialized regulatory activity. The AEC is responsible for preventing contamination from nuclear powerplants, and the FDA maintains surveillance of shellfish-growing areas. Those that are contaminated by pollutants are closed to harvesting by responsible State shellfish-control agencies.

All Federal agencies conduct programs to evaluate the effects of ship and shore facility operations on the environment and to control or prevent the discharge of pollutants resulting from these activities. Because of the number and variety of its ship and shore establishments, the largest and most complex of these programs is that of the Department of Defense. In addition, the Navy has initiated a program to collect environmental data in naval harbors and is monitoring sites where munitions have been previously dumped to assess possible environmental effects of these operations. All Federal agencies are also involved in the preparation and review of Environmental Impact Statements in which the environmental effects of proposed construction or other actions are analyzed and alternatives evaluated.

Containment and Recovery of Oil Spills

Present technology for reducing damage from massive oil spills is inadequate, and techniques for cleaning up even small oil spills are effective only in calm waters. Federal programs are now underway to improve methods and equipment for combating spills.

The Coast Guard program includes technology to limit the quantity of oil released, to control the spread of released oil, and to remove the oil from the water's surface. It has developed a near-operational, air-deliverable, emergency transfer and temporary storage system consisting of collapsible 500-ton temporary storage containers and a pumping system. To restrict the spread of spilled oil, a system of containment booms, suitable for use at sea, is under development; the prototype boom has undergone preliminary tests in the Gulf of Mexico. It is designed to contain oil slicks in 20-mile-per-hour winds and 5-foot waves and to survive 40-mile-per-hour winds and 10-foot seas. A recovery system is in the initial stages of development. The goal is an oil recovery rate of 2,000 gallons of oil per minute in 20-mile-per-hour winds and 5-foot seas.

Program emphasis of EPA's Oil Pollution Program is on developing systems and engineering prototypes for the prevention of oil spills and the containment and recovery of oil. Specific interest is centered on the development of techniques for the removal of oil from water with the aid of sorbent materials and mechanical equipment and the development of techniques for the restoration of oil-contaminated beaches. An Oil and Hazardous Material Test Basin providing a controlled environment is being constructed at Edison, N.J., to test and evaluate devices to treat, control, and remove spilled materials. New boom systems for use in high-velocity rivers and tidal regions, onshore ballast treatment systems, and remote automatic oil-skimming concepts will be demonstrated in the year ahead.

The Hazardous Material Spills Program has as its primary objectives the development of devices to prevent spills, methods and equipment to detect and identify spills, and countermeasures equipment to lessen the environ-

mental effects of spills. Current efforts are focused on the development of first-generation devices to prevent, detect, and control material released by accidents at production sites, storage facilities, and in transit. Full-scale demonstrations of these techniques and systems will be conducted at the Edison Test Basin next year.

The Navy's oil spill program is directed toward the development of improved tank-content indicators and slop tanks to prevent oil spills, rapid-response methods for containing and removing spills of up to 10,000 gallons, and such new spill-control techniques as the use of emulsion burners and chemical treatment to increase surface tension for facilitating cleanup operations.

The Corps of Engineers has investigated techniques for combating oil spills utilizing absorbent materials for soaking up oil which then sink to the bottom. In view of its large dredge fleet, the Corps is developing mechanisms that can be attached to the dredge and provide support in combating oil spills. In addition, investigations have been made on using biological organisms to attack the oil spilled.

Oil-Water Separation Equipment

Under the Water and Environmental Quality Improvement Act of 1970, the discharge of oil in navigable waters of the United States or in the waters of the contiguous zone to the 12-mile limit is prohibited except under special circumstances. Nonetheless, oil-water mixtures from bilges and ballast are sometimes unintentionally discharged in these waters, and the resulting oil slick may be harmful to fish and wildlife, beaches, and shoreline property. The use of rapid, efficient oil-water separators would put an end to this type of accidental discharge. The Maritime Administration, Navy, and Coast Guard are currently cooperating in a program to develop reliable separators for use in public and commercial vessels. Separator development has shown some progress with three prototype gravity separators used successfully on tankers for 1 to 3 years.

Ship Waste Treatment

Although they constitute only a small fraction of 1 percent of all municipal, industrial, and other wastes entering the marine environment, ship wastes are sufficient to endanger water quality in harbors, estuaries, and some near-shore waters. No single shipboard waste treatment system can meet the needs of all of the diverse types of vessels afloat. In recognition of this problem, four Federal agencies are engaged in efforts to develop specialized treatment systems adapted to specific vessel classes.

The main thrust of the Maritime Administration program is the development of treatment equipment and operational techniques to minimize waste discharges from commercial ships. A secondary effort is directed to the conversion of reserve ships for use as port waste treatment facilities.

The EPA Program is concerned with controlling waste discharge from small watercraft. It is currently completing work on first-generation devices for primary treatment of human and other wastes. This will be followed by

development of devices capable of providing more complete treatment of wastes.

The purpose of the Navy program is to reduce, or render harmless, sanitary, domestic, and other waste discharges by a wide variety of Navy vessels. The Navy is developing a pollution-free shipboard incinerator for combustible solid wastes and a compactor and encapsulator for noncombustible wastes. It is installing three 500-man sewage treatment units for shipboard evaluation and is awarding contracts for further development of shipboard sanitary-waste treatment and disposal units.

At the same time, the Navy is proceeding with the development of a shipboard integrated-waste-management system for treatment of sanitary, domestic, and industrial wastes. This will involve evaluating new ways to handle sanitary wastes and determining the limits of their capabilities to handle other types. When a selection is made, shipboard endurance tests will be conducted before final engineering development.

The Coast Guard program is directed to the development, or adaptation, of waste treatment facilities for use on Coast Guard cutters, icebreakers, and shore facilities.

Recreation

The attraction of the ocean for man is quite profound and quite subjective. Intangibles determine much of what is sensed and thought about the marine environment by the millions of Americans who go to the sea and to the Great Lakes for recreation. At the same time, recreation in the marine environment is related to the enormous and very real income produced by leisure life activities in the United States. The Federal Ocean Program reflects this total scope of recreation, with emphasis on extending and enhancing those areas set aside for public use.

With matching funds of the coastal States, counties, and local governments, the Land and Water Conservation Fund, administered by the Department of the Interior's Bureau of Outdoor Recreation, continues to serve as the principal source of support for the planning, acquisition, and development of coastal recreation areas and facilities. The Fund also serves to acquire lands for the National Wildlife Refuges, which are administered by the Bureau of Sport Fisheries and Wildlife (BSFW), and for the National Park System. New National Parks, Recreation Areas, and Refuges established during 1971 and proposed for establishment are listed in table II–1.

Of the proposed Parks and Refuges shown in the table, the Gateway and Golden Gate National Recreation Areas constitute new experiments in the protection and maintenance of recreational resources. These two are located in and near large, dense urban centers where use and competition for shoreline development are already intense and where commercial interests are encroaching on and conflicting with recreational values. Through proper management of the resources, visitor services, and protection and development of recreational uses, there is real potential for enhancing the present beaches for the benefit of the nearby urban population.

To assist in the preservation of recreational values, the Corps of Engineers is cooperating with the National Park Service in North Carolina and the

Great Lakes on shoreline stabilization problems. Research has started toward development of additional surfing opportunities on the California coast. During 1971, the Corps of Engineers completed a national assessment of beach and shore erosion problems for use by Federal, State, local, and private interests in shoreline planning, land-use regulation, and protection. The conclusions of the National Shoreline Study show a pressing need for: Coordinated action by Federal, State, and local governments and by corporate and private owners to arrest erosion of the national shorelines; coordinated and comprehensive planning and management to insure the shoreline use in the national interest; intensified research and investigation of the processes contributing to shore erosion; and development of improved erosion-control methods.

Table II-1

Parks and Refuges Established by Congress During 1971

Gulf Islands National Seashore, Fla. and Miss.
Farallon Islands National Wildlife Refuge, Calif.
San Pablo National Wildlife Refuge, Calif.

Parks and Refuges Proposed to Congress, 1971–72

Cumberland Island National Seashore, Ga.
Guam National Seashore, Guam
Sandy Hook National Seashore, N.J.
Gateway National Recreational Area, N.J.-N.Y.
Golden Gate National Recreation Area, Calif.
Channel Islands National Park (enlargement of present Channel Islands National Monument), Calif.
Gardners Island National Monument, N.Y.
Puukohola National Monument, Hawaii
Humboldt Bay National Wildlife Refuge, Calif.
San Francisco National Wildlife Refuge, Calif.

Following current review of this report by States and Federal agencies, it will be submitted to the Administration and Congress. During Fiscal Year 1973, the Corps' general study will be complemented by detailed studies of the oceanic, estuarine, and Great Lakes shorelines for protection against erosion and hurricane-induced flooding, initially off the coasts of Texas, Louisiana, North Carolina, and the New York City, N.Y., metropolitan area.

While not directly related to protection of the marine environment, a very important consideration is the *safe* recreational use of the environment by ever-growing numbers of boaters. President Nixon, in August 1971, signed into law the Federal Boating Safety Act of 1971 designed to improve boating safety and to foster greater development, use, and enjoyment of all the waters of the United States by addressing a number of problems presented by the growing number of recreational boats, among them an ever-increasing number of accidents and fatalities.

The Coast Guard, acting for the Secretary of Transportation, has been given broad authority to improve safety for the recreational boating public in a number of important areas.

One facet of the Act seeks to insure that a basically safe boat reaches the consumer. Under this authority, the Coast Guard will issue regulations and

standards to boatbuilders for the safety aspects of new boats and equipment. The manufacturer will also be required to maintain a list of first purchasers to permit product recall or repair in the event that subsequent safety defects come to light. A landmark provision of the Act is that the builder must do this at his own expense.

The first of these regulations, expected to become effective next summer, will apply to boats under 26 feet (where most fatalities occur) and will establish minimum requirements for lifesaving devices, safe loading, safe powering, and flotation. Following regulations will deal with the hazards of fire and explosion.

Other provisions of the Act consider the boat operator. The Coast Guard has been provided resources to increase efforts in motivating the average boatman to safe operation and to require him to follow the boating laws and regulations. It was also authorized to act before the fact in accident prevention. Coast Guard boarding officers now have authority to require operators of boats exhibiting especially hazardous conditions to have those conditions corrected before permitting them to continue.

Minimizing Effects of Construction and Development

Passage of the National Environmental Policy Act of 1969 and recent court decisions have given substantial incentive and support to eliminating or reducing the undesirable consequences of marine environmental alterations. During 1971, most Federal agencies expanded their ability to prepare and evaluate Environmental Impact Statements and the scope of their consideration. For example, additional emphasis was placed on the potential threat to marine resources from development of the Alaska North Slope and offshore fuel reserves; alternatives to such development, such as increased oil imports, were also scrutinized with an eye to environmental impact.

Coastal Engineering

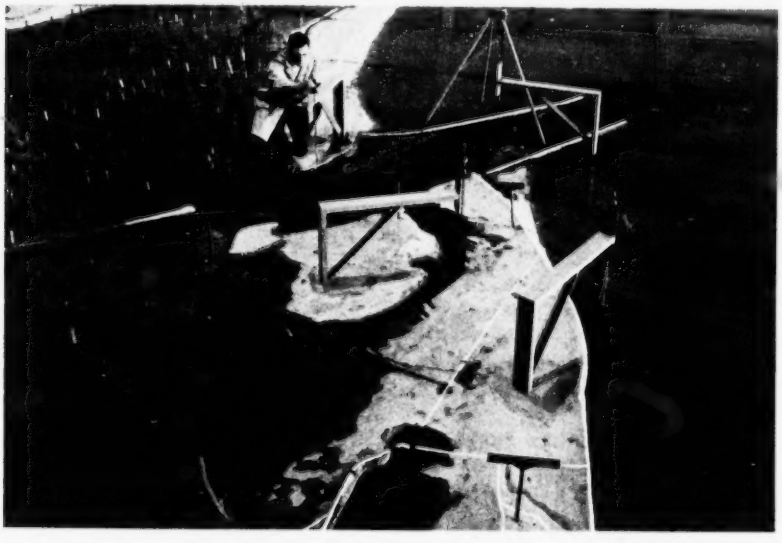
The Corps of Engineers continued studies initiated in 1968 to evaluate the impact of dredge disposal on the Great Lakes, to improve water quality, and to reduce polluted spoil. A study to identify needed research on the effects of engineering activities on coastal ecology from Maine to Alaska, including the Great Lakes, was completed in 1971. Results of these studies are now being implemented in a number of ways. Recommended research on techniques for creating new marshlands from dredge spoil is being supported at three universities. For the Great Lakes, the Corps received legislative authority to construct structures to retain polluted dredge spoil. Currently, potential sites are being evaluated in conjunction with the States of the Great Lakes region. Research at the U.S. Army Waterways Experiment Station in Vicksburg, Miss., is also underway to develop new technology for maintaining channels and disposing spoil. This program will be generally applicable to all coastal regions of the United States. The Corps' physical models of major estuaries at Vicksburg have also been used to study environmental impact problems. For example, design criteria to minimize the impact

of enlarging the Delaware-Chesapeake Canal utilized a scaled physical model of Delaware Bay.

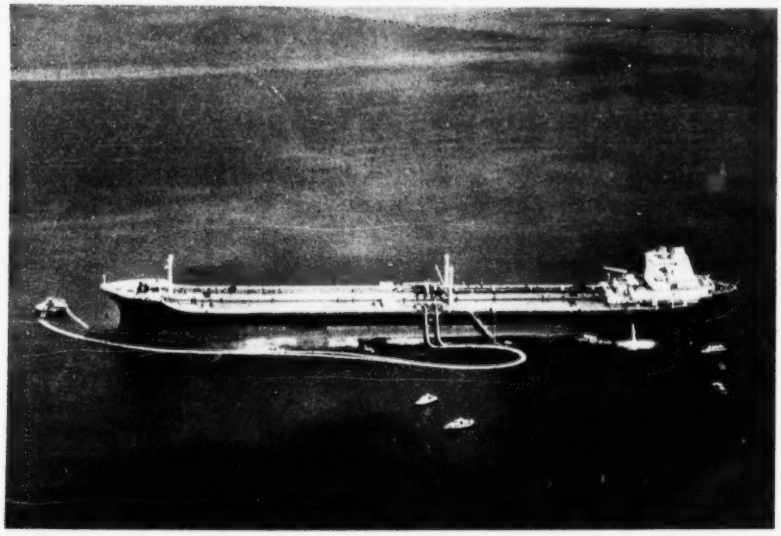
Marine Mining

The tapping of offshore mineral resources is growing year by year as new technologies permit mining operations to move into the oceans and Great Lakes. The demand for sand and gravel is generating much offshore activity, the environmental impact of which is not clearly understood. To provide such information, the Office of Sea Grant has funded the investigation of ecological effects of sand and gravel operations. This study has subsequently expanded into an interagency program involving NOAA, the Corps of Engineers, USGS, and EPA. Information will be acquired before, during, and after mining operations to evaluate the potential changes in currents, shore processes, and the ecosystem in general.

One such program is being conducted by NOAA's Marine Minerals Technology Center in cooperation with the State of Massachusetts and the University of New Hampshire. The objectives of this project include the development of the capability to predict environmental effects of mining operations and, subsequently, to establish control techniques for industrial development of extraction systems compatible with the environment. The Center has similar programs aimed at defining the ecological impact of heat, wastes, turbidity, sediment displacements, bathymetric alterations, and other known and as yet unknown side effects of marine mining.



Physical and mathematical models of coastal and estuarine areas are seeing increased application in the Federal Ocean Program. Here, a Corps of Engineers scientist works on a hydraulic model of the Texas coast near Galveston; storm surges, tides, and tidal currents are simulated by a wave generator.



A large tanker discharges its cargo at a terminal located two and a half miles off Singapore in about 88 feet of water. Such terminals have been proposed for our Atlantic and Gulf Coasts as a means of easing problems of congestion and collision-caused marine pollution; but their development is being accompanied by intensive studies of possible ecological impact.

Construction for New Energy Supplies

The energy demand in a highly industrialized Nation like the United States provides two related problems with major impact on the environment. The first of these is the development of deepwater ports for receiving deep-draft supertankers. There are few ports capable of handling such ships today. Congress, recognizing the national need for resolving this problem, has passed resolutions directing the Corps of Engineers to investigate the suitability of offshore sites along the North Atlantic coast from Maine to Norfolk, Va., and along the gulf coast from Texas to Tampa Bay, Fla.

In December 1971, the Corps published *Foreign Deep Water Port Development,* a selective overview of the economic, engineering, and environmental factors. A second study, *U.S. Deep Water Port Needs,* is in process. Two separate studies will also be published in 1972 concerning the experiences of Japan and Eurasian areas with deepwater ports. The Corps and the Maritime Administration (which is investigating the feasibility and environmental implications of offshore port facilities) are coordinating their efforts to provide joint recommendations for ways of meeting this national objective.

A second part of the energy problem is related to the siting of nuclear powerplants. Because of the rapidly expanding population along the coastal areas and the resulting shortage of adequate shore sites, the power industry has given consideration to areas off New York City and the New Jersey coast. The siting of these plants must consider the total environmental impact on the specific locale for which they are planned and the possibility

of combining such operations with offshore port facilities and other possible uses.

For shore plants, the AEC, following the court action on the proposed Calvert Cliffs nuclear powerplant in Maryland, revised its Environmental Impact Statement requirements for all nuclear powerplants, including those scheduled for coastal area construction. Prior to the court decision, only radiological matters were included in the Impact Statements evaluated by the AEC. Now, discussion of all environmental factors is being required.

International Affairs

In February 1971, President Nixon directed that the United States take international initiatives to promote the banning of unregulated ocean dumping and to place strict limits on ocean disposal of wastes harmful to the environment. To this end, the U.S. delegation to both meetings of the Inter-Governmental Working Group on Marine Pollution for the June 1972 United Nations Conference on the Human Environment proposed a draft ocean-dumping convention which would require the establishment of national systems to regulate ocean dumping with internationally agreed principles for the protection of ocean water quality and the marine envinronment. No conclusive action was taken, so a third intergovernmental meeting was held at Reykjavik, Iceland, which produced draft articles for such a convention for consideration and action at the Conference. Also included for consideration at this Conference are a comprehensive plan for combating marine pollution and a number of proposals concerning the establishment of a worldwide network for monitoring the land, sea, and air environments.

The United States also made proposals in the United Nations Law of the Sea Preparatory Committee for the regulation of marine pollution arising from exploration and exploitation of the resources of the seabed and subsoil.

On October 14, 1971, the United States deposited instruments of ratification of the 1969 Inter-Governmental Maritime Consultative Organization (IMCO) Intervention Convention and the 1969 amendments to the 1954 IMCO Oil Pollution Convention. These international agreements, respectively, authorize coastal States to take necessary measures to prevent, mitigate, or eliminate "grave and imminent" danger of oil pollution to their coastlines and to extend the area of application and increase the stringency of all discharge standards in accordance with the 1954 Convention. The effect of these measures will be strengthened as a result of the international Convention on the Establishment of an International Compensation Fund for Oil Pollution Damage, negotiated by 49 countries in December 1971, to insure that full and adequate compensation will be available to victims of oil pollution incidents.

The North Atlantic Treaty Organization (NATO) Committee on the Challenges of a Modern Society passed a resolution calling for the prohibition of all intentional discharges of oil in the course of vessel operation by 1975 or at least by the end of the decade. This resolution is now being implemented in a draft convention being prepared by IMCO with U.S. support. The draft convention will also deal with prohibitions on the discharge of noxious substances. International agreement on this convention will be sought at the 1973 IMCO Conference on Marine Pollution.

At its Seventh Biennial Session late in 1971, the Intergovernmental Oceanographic Commission (IOC) endorsed the Global Investigation of Pollution in the Marine Environment (GIPME) as a major IOC project. The purpose of GIPME is to provide the research base for planning pollution monitoring and control programs throughout the world ocean. The environmental quality programs of the IDOE are described in chapter VI.

Environmental quality in the Great Lakes was also a subject of international concern in 1971. The United States-Canada ministerial meeting on Great Lakes pollution in June resulted in the decision to establish common water-quality objectives based on recommendations of the International Joint Commission. The Great Lakes Water Quality Agreement, signed on April 15, 1972, and contingent upon appropriate legislative action, commits the two Governments to the development of compatible water-quality standards and to the implementation of a variety of pollution control programs within agreed time periods. These controls include construction of treatment facilities for municipal and industrial wastes and animal husbandry operations; reduction of phosphorous discharge; elimination of mercury and other toxic heavy metals from discharges; control of thermal pollution; control of pollution from radioactive wastes; control of pollution from pesticides; and development of controls for pollution from combined sewer overflows. The two Governments had earlier agreed on assignment of additional responsibility and authority to the International Joint Commission, strengthening efforts to restore and protect Great Lakes water quality. The Commission would be given a greater role in surveillance of water quality in the Great Lakes, monitoring of the effectiveness of governmental programs to achieve the common water-quality objectives, making recommendations for legislation and programs, and coordinating activities to achieve improved water quality in the Great Lakes.

Chapter III

DEVELOPING AND MANAGING MARINE RESOURCES

The resource potential of the marine world attracts increasing attention here and abroad as human needs look seaward for food and feed and for critical mineral resources. With this preoccupation with natural wealth, incompletely tapped, has also come a growing consciousness that past mistakes in using these rich resources must be corrected and avoided in the future.

There is much evidence of this evolving trend in the Federal Ocean Program. For example, resource management has come to mean more than just the efficient use of a self-renewing stock of fishes; it also means the conservation of endangered forms of life for their own sake. Similar emphasis appears in reports of progress from nonliving resource programs. Marine minerals, for example, must not be mined if they cannot be recovered by ecologically tolerable techniques.

Wise resource management in the marine environment has become a pressing matter, and, as conflicting uses, jurisdictions, and laws spring up around this issue, it becomes an increasingly complex, elusive goal. In the coastal zone, the Federal Government shares resource management responsibilities with State and local governments. Beyond territorial limits of the individual States, the Federal Government has sole responsibility for encouraging, supporting, and managing resource development. Here it must coordinate diverse industry, guide our national and international interests, resolve potential conflicts of use, and provide information and services that assure safety and protect industry operations and investments.

Within this framework, the Federal Ocean Program has been moving to develop the comprehensive knowledge of living and nonliving resources that is a condition for any successful resource management scheme. Through its ties with the States and other nations, the Federal Government is applying new knowledge and technology to the problems of protecting and allocating living resources, assisting our fishing industry and its consumers, conserving endangered species, and discovering and tapping the nonliving resources of the sea.

A recently developed shrimp trawl, used in waters of the Pacific Northwest, brings up a 1,500-pound catch of clean shrimp. Unlike the standard trawl which nettled, along with the shrimp, other forms of bottom life, this new method separates out a clean, high-quality shrimp catch with less crew effort.

Living Resources

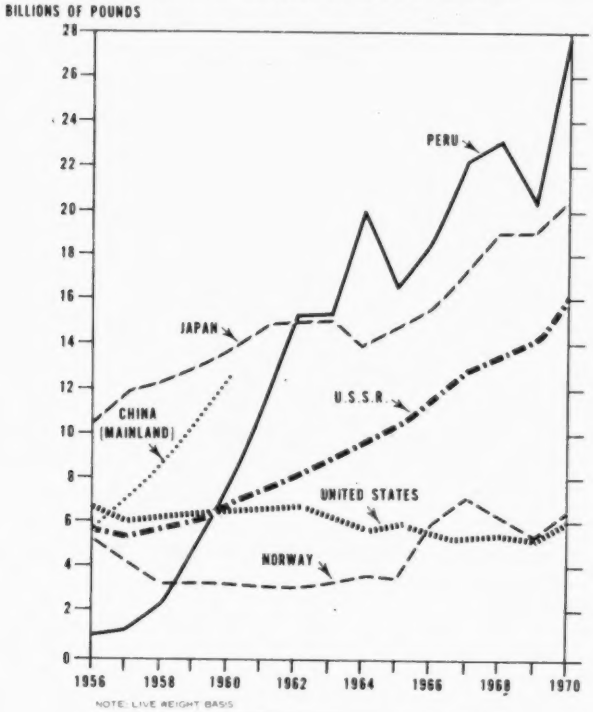
Historically, our major marine prospecting has been for the varied and valued forms of life which animate the sea and which support those who hunt, harvest, and sell them. Hunger and economic pressures, not wonder or human curiousity, have impelled our main connection with oceanic life; and we have become, as a species, the most successful of marine predators.

Our national success has been less spectacular.

Since 1956, the United States catch in poundage has dropped from second to sixth place among the fishing nations while domestic and world demands and the world fish catch have continued to increase. The annual domestic demand for fish, currently 11.5 billion pounds, is expected to increase to 14 billion pounds by 1980. Of the current demand, only 4.9 billion pounds come from the fishing efforts of 13,600 U.S. vessels and more than 65,000 boats; 57 percent of the demand is met by imports, with the larger part of this demand (32 percent) being edible fish and the remainder industrial fish. The result has been an adverse balance-of-payments rate of more than $900 million annually.

A viable fishing industry for the United States means solving difficult root problems: The common property nature of the resource; lack of knowledge

CATCH OF SEAFOODS BY LEADING COUNTRIES



NOTE: LIVE WEIGHT BASIS
SOURCE: "YEARBOOK OF FISHERY STATISTICS 1970" VOLUME 30, FOOD AND AGRICULTURE ORGANIZATION

of resource potential; ineffective management; a generally depressed fishing industry; and competition by superbly equipped foreign fishing fleets. There are also serious problems of environmental degradation, particularly where estuarine-dependent species are concerned. In some areas—the New York Bight is an example—marine pollution has affected commercial and recreational fisheries to an undetermined degree, and further environmental deterioration in estuarine and coastal areas can only produce the same negative result.

The Federal Ocean Program is striving to provide answers and aid to our sport and commercial fisheries and the industries they support and to retrieve threatened forms of marine life from the brink of extinction.

Resource Management

Effective management of living marine resources is concerned with conserving (through controlled harvesting) existing stocks, developing new ones, and determining how these stocks are to be allocated among competing fishermen. It is also increasingly concerned with the interrelations between marine life and the physical environment.

During 1971, a State-Federal program, sponsored by NOAA, was started to provide integration of biological, economic, legal, and social information in an effort to overcome the legal and institutional constraints which inhibit efficient resource utilization and to establish the framework for allocation. Steps were taken by regional teams to define specific local problems and to plan, with local agencies, for developing solutions. About 700 project grants were made to States for biological research, construction of fish hatcheries, research laboratories and vessels, and research on controlling jellyfish and algae. Also included were projects to alleviate resource disasters caused by hurricanes, fish diseases, and other natural phenomena. Two such disasters occurred in Fiscal Year 1972 when oyster resources were destroyed by natural causes in Mobile Bay, Ala., and Escambia Bay, Fla.

NOAA and the BSFW participated in an analysis of the environmental impact of such activities as dredging, filling, waste disposal, channel construction, reservoir construction, power generation, and drainage to conserve and enhance the marine, estuarine, and anadromous living aquatic resources.

The Corps of Engineers funded academic institutions in North Carolina to conduct research on utilizing unpolluted spoil and selected grasses. This has proven successful in forming biological communities on the test sites. The Office of Sea Grant has since expanded this program, and additional research is being accomplished in Savannah, Ga., and Mobile, Ala., by the Corps.

Sport fishermen account for a large portion of this country's catch of salt-water fish, but the size and real value of their catch have not been fully identified. Obtaining detailed statistics has been difficult. However, recent studies conducted for NOAA by the Bureau of the Census reveal that some 9.5 million anglers fished in salt water in 1970 and spent $1.4 billion. This was an increase since 1965 of over one million anglers and an increase in average annual expenditure per angler from $96 to a total of $129.

Many commercially important marine species are also important to sport fishing, now increasingly recognized as a major element in fisheries management plans. Shown here is the winning catch of the 1971 U.S. Atlantic Tuna Tournament.

Salt-water "angler-days" for 1970 totaled 113,694,000, with greatest participation centered on the heavily populated Atlantic coast. These and similar statistics are guiding the design of Federal programs for addressing allocation problems between commercial and sport fishing interests.

Of concern to the U.S. fishery is the increasing competition offshore from foreign fishing fleets. In February 1972, for example, more than 550 foreign fishing vessels and fishery-support ships were sighted, most of them off New England, the Middle Atlantic States, and Alaska.

The United States is party to 15 international fisheries agreements. To insure observance of fishing regulations and treaties by both foreign and

domestic fishermen, an increasing surveillance capability and enforcement activity is provided cooperatively by the Coast Guard and NOAA through aerial and surface patrols. In 1971, a total of 163 violations of fishery agreements were observed involving foreign vessels; 11 seizures resulted in penalties of $246,000.

Resource Assessment

The ability to monitor, assess, and predict the abundance and distribution of fish populations remains the keystone in developing fully successful techniques of resource management. During 1971, NOAA initiated a coordinated Marine Resources Monitoring, Assessment, and Prediction (MARMAP) Program to define the kinds and quantities of living marine resources available and to provide a comprehensive data base for domestic and international management. Surveys will be conducted for fish larvae, groundfish, and pelagic fish to determine the spatial and temporal extent of their populations. These surveys will be supported by biological and physical oceanographic studies conducted by Federal and State agencies, universities, and international organizations.

In December 1971, the first step was taken toward a model Federal-State marine resource development program. A grant was made by the Coastal Plains Regional Commission (CPRC) to North Carolina for construction of the research, education, and extension program facilities needed to develop fully the marine resources along its extensive coastline. Eventually, the program in North Carolina will complement similar programs in South Carolina and Georgia, thus furthering progress toward the CPRC goal of stimulating economic development in the coastal regions of the three States.

The plan for this model program is now being formulated. As the principal Federal agency in the partnership, NOAA and its components will participate actively in such areas as: Advisory services, training, and aquaculture (Office of Sea Grant); exploration and assessment of onshore fishery stocks (National Marine Fisheries Service); hydrography, circulation, and geophysical studies for estuarine areas and the Continental Shelf (National Ocean Survey); and marine forecasts at several stations along the coast, with additional information on recreational and commercial fishing supplied by State agencies (National Weather Service). As this program develops in Fiscal Year 1973, other Federal agencies will be invited to participate.

Aid and Alternatives for the Fishing Industry

The fishing industry responds as few others to the forces which shape the harsh life of the marketplace. It is a technology-dependent industry, vessel-oriented, and linked absolutely to the availability of marketable fish; it is also profoundly influenced by such incalculable and complex issues as conservation, public health, and life cycles in the sea. For this reason, industry-aiding projects play an important part in the total Federal commercial and sport fisheries effort, as do attempts to dilute the high-economic risk of fishing through the development of economically viable alternatives such as aquaculture.

Research toward improved harvesting and handling techniques is an important ingredient here. An example of this type of aid is the development, during 1971, of an improved chilled sea-water holding system adaptable to certain fisheries (for example, salmon and tuna). The new system, cooperatively developed by NOAA and the fishing and metal industries, uses titanium alloy to prevent corrosion and carbon dioxide added directly to the chilled sea water to reduce spoilage of the catch aboard the fishing vessel. Help is also provided industry in the form of technological development data, market news, and economic analyses.

In 1971, under the Fish and Wildlife Act of 1956, 255 of 443 applications received for the Fisheries Loan Fund were approved for $6.8 million, and 59 of 65 applications received for Fishing Vessel Mortgage Loan Insurance were approved for $9.1 million. Federal economic aid also includes providing financial assistance that offsets certain costs resulting from policies of other nations which the U.S. views as inconsistent with international law. An example of this is Federal payment of fines when U.S. flag vessels are seized while fishing on the high seas off South America.

Additional public services provided by the Federal Government include extension and technical services aimed at the consumer and homemaker that emphasize fish-purchasing methods, fish cookery, and nutritional education to improve the national diet.

The Federal Government continues its efforts toward developing practicable and economic methods of producing fish protein concentrates (FPC), a promising, high-protein food additive. During 1971, a pilot plant to make FPC from underutilized fish began operations under contract at Grays Harbor, Wash., to demonstrate process feasibility and to provide cost data and FPC for research. The FPC produced there will be supplied to the Agency for International Development (AID) for protein-supplement studies in developing countries, to American industry for product research and development, and to universities for basic product studies.

The NOAA and BSFW anadromous fish restoration and enhancement programs, with matching funds from States, contribute significantly to the protection and development of living resources by restoring runs of anadromous fish damaged by water development projects on the Columbia River, as provided for by the Mitchell Act. Included in these activities are the construction and maintenance of hatcheries and of fish screens and ladders for migrating salmon and steelhead.

In 1971, BSFW fish hatcheries produced over 52 million young of several anadromous species to stock the Nation's coastal rivers and Great Lakes. State hatcheries along the west coast contributed approximately 20 million pounds of coho, fall chinook, and steelhead to the commercial and sport catch. The newly built Willamette Falls Fish Passage Facility in Oregon will increase Willamette River fish runs by about 180,000 salmon and steelhead, providing at least 250,000 new angler-days per year.

Other progress during 1971 included further construction of artificial reefs to increase angling opportunities by concentrating sport fish populations. Tagging of deep-sea gamefish and coastal species continues to provide information needed to assess populations and study migrations.

Aquaculture developments are providing the basis for important contributions to resource and economic development. The objective of the Federal effort is to develop the methodology and demonstrate the biological, economic, and engineering feasibility of aquaculture systems as a means of establishing fisheries under man's control. Basic NOAA programs provide important spinoff information which is critical for the development of a commercial aquaculture system.

A Sea Grant-supported private company demonstrated that chinook and coho salmon can be reared in floating net pens with good feed-conversion efficiencies. This commercial-scale demonstration in Puget Sound began in November 1970 with 700,000 coho eggs. The coho fry, together with 500,000 chinook fry, were reared in fresh water in a conventional way except for the use of heat to speed growth. In the summer of 1971, 500,000 juveniles were transferred to salt-water rearing pens. The fish are to be harvested at pan size during the spring of 1972. (Other Sea Grant activities are discussed in chapter VI.)

Quality Assurance

Various types of screening activities are carried out by FDA to insure that only safe, wholesome fishery products reach the consumer. Factors governing the toxigenicity of *C. botulinum* in certain fishery products were defined last year to provide a reliable margin of safety in the distribution and storage of semipreserved fishery products. Selected fishery materials and processed products were screened to identify species and situations in which potential hazards could exist because of the presence of toxic materials such as mercury and pesticides.

Studies during 1971 aimed at defining the extent of mercury contamination of fishery products indicated that virtually all edible salt-water fish offered on the American market were safe and wholesome. Initial alarms regarding tuna turned out to be of little real concern after analysis of the U.S. canned tuna supply, which showed that less than 4 percent of the fish examined exceeded the FDA mercury guideline of 0.5 part per million. FDA laboratories conducted an intensive survey of the 19 most important commercial fish for mercury contamination and found the levels of mercury in salt-water fish to be quite low, about 0.09 part per million. From over 1,000 lots examined, the FDA initiated seizure or recall actions against 14 lots of snapper, three lots of bonito, and three lots of mackerel.

Swordfish was the only species which consistently exceeded FDA mercury guidelines. Swordfish from all cold storage facilities and points of entry into the United States were examined for mercury early in 1971. This survey revealed that only 42 of 853 swordfish sampled were within the guideline and 53 percent contained mercury concentration exceeding 1 part per million. Accordingly, on May 6, 1971, the Commissioner of Food and Drugs issued a public warning against the consumption of swordfish.

NOAA is vigorously pursuing a series of programs aimed at determining the levels and effects of heavy metals occurring in fish and fishery products. The effort here has concentrated on major fishery products—Pacific halibut, northern lobster, cod, haddock, pollock, sole, black cod, fishmeal, billfish, tunas—going to consumers. One result of this activity is a procedure that

A Food and Drug Administration inspector checks the temperature of crabmeat being canned as part of an overall inspection of processing plant sanitary controls.

enables the halibut industry to sort fish by size and geographic area of harvest, greatly reducing mercury levels and reducing the time and cost involved in assuring fish products which comply with FDA standards. These studies may also offer a basis for managing other fishery resources which are or may become involved in environmental contaminant problems.

Because the physiological effects of contaminants, such as heavy metals and chlorinated hydrocarbons, and the pathways by which they penetrate the marine ecosystem are not fully understood, NOAA began a study in 1971 aimed at developing this knowledge. The study is focusing on the marine ecosystems of the New York Bight, the California Current, and saltmarsh estuaries along the Middle Atlantic coast of the United States.

At the request of the AEC, the National Academy of Sciences last year prepared a report updating and summarizing current knowledge concern-

ing radioactivity in the world oceans. The resulting publication, *Radioactivity in the Marine Environment*, shows that many of the concepts that pertain to our understanding of the behavior of radioactivity in the oceans can be applied to studies of other wastes discharged to the marine environment. For example, the oceanic distributions of radioactivity have served as tracers of water masses, sediment movement, and various biological parameters. The studies of the accumulations and redistributions of radioactivity by marine organisms have served to highlight food web relations that can be valuable in predicting the behavior of the stable element counterparts of the radionuclides studied.

A voluntary inspection and grading program funded by industry is also carried out to assure that fish processing plants meet established sanitary and safety requirements. In 1971, NOAA inspectors checked and certified 350 million pounds of fish and fishery products, representing about 27 percent of total 1971 fishery production in the United States.

Public service activities will continue to provide consumers (and industry) with basic information concerning the composition, nutrition, and safety of fishery products. Enactment of the Wholesome Fish and Fisheries Products bill now being considered by the Congress would strengthen Federal services to protect the health and welfare of the consumer.

Endangered Species

The plight of many species of marine wildlife, driven toward extinction by excessive harvesting, destruction of native habitats and food supplies, and environmental pollution, has become a subject of intense concern here and abroad.

Eight different species of whales have been placed on the endangered species list, including the sperm whale shown here surfacing off the coast of Southern California.

At present, eight species of whales, including all baleens, sperm, finback, and sei, are on the endangered species list maintained by the BSFW. In a move to ease predatory pressures on these marine mammals, the Secretary of Commerce ended commercial whaling in the United States on December 31, 1971, and the Secretary of the Interior prohibited the importation of whale products. Even though the industry had dwindled to only one operation by the end of 1971, the United States has committed itself to preventing the extinction of these and other endangered species.

The U.S. delegation to the International Whaling Commission Meeting last year led efforts to establish more effective regulations for conservation of the three species of whales being taken under Commission regulations. Although success was limited, quotas were reduced by 20 percent, and both Russia and Japan tentatively agreed to allow observers from other nations to accompany their whaling fleets and inspect their land-based operations during the 1972–73 season. The United States will provide observers through the Department of Commerce.

In addition to the whales, the BSFW Endangered Species Lists include the dugong, two varieties of manatees, several kinds of shoreline birds-of-prey and migratory waterfowl, marine turtles and tortoises, and two species of fish found in the Great Lakes. Although reduction in the populations of several of these can be attributed to hunting and exploitation, others, such as the brown pelican on our west coast, have suffered most from changes and degradation of their habitats and food supplies.

During 1971, the United States also coordinated initiatives with the Soviet Union, Canada, Mexico, and other nations aimed at protecting endangered species which live in the Arctic or migrate along the west coast. Further, final preparations for a plenipotentiary negotiating conference on wildlife conservation in Washington in 1972 are well underway. All United Nations member nations will be invited to participate.

A treaty that would protect several species of seals living and breeding on the pack ice and in the sea around Antarctica was also the subject of preliminary negotiations last year. A conference held in London, United Kingdom, in February 1972 produced a draft convention on antarctic seals which will be open for signature there from June through December 1972. The treaty provides protection in the form of catch quotas, absolute bans on hunting certain species, and closed seasons and zones.

Public attention was caught last year by reports of high mortalities among porpoises in the yellowfin tuna fishery. Tuna fishermen follow porpoises to yellowfin schools and inevitably some of the marine mammals are trapped by the seine nets. Last year, tests conducted by commercial fishermen in cooperation with NOAA showed that mortality can be reduced about 75 percent by using modified purse seines and porpoise-release techniques developed by the tuna industry.

As stated by the President in his Environmental Message of February 8, 1972, the Endangered Species Act of 1969 does not provide the kind of management tools needed to act early enough to save a vanishing species. For the present law to have any effect, native species of fish and wildlife must be found to be actually "threatened with destruction." Current pending legislation supporting the Presidential initiative (H.R. 13081, "Endangered

Species Conservation Act of 1972") will strengthen the Departments of Commerce and the Interior in their efforts on behalf of threatened forms of fish and wildlife. It will provide earlier identification for endangered species and authorize that protective action be taken *before* a species becomes so depleted that its revival is difficult or impossible. Most important, this legislation will make the taking of endangered species a Federal offense. Other pending legislation includes bills to establish a fund for endangered wildlife and to implement the intent of the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere.

With the addition of the Farallon Islands and San Pablo National Wildlife Refuges, the BSFW administers 91 coastal, island, and estuarine areas with over 2,500 miles of shoreline and 20.5 million acres of land and water for the protection of fish, wildlife, and recreational values. Among the better known is the Aransas National Wildlife Refuge, Tex., which provides the winter home for the endangered whooping crane. During 1971, a research program was initiated with Texas A&M University on the effects of siltation, sediment drift, and water turbidity on the ecology of San Antonio Bay, which adjoins this refuge.

Nonliving Resources

In his Energy Policy Statement, submitted to the Congress in June 1971, the President noted a need for "acceleration of oil and gas leasing on the Outer Continental Shelf, along with stringent controls to protect the environment." This need was evident in the widespread restrictions on new uses of gas, one of our cleanest energy sources, and by substantial increases in oil imports, which now contribute more than 25 percent of this Nation's requirements and are becoming a significant component of the current unfavorable balance of trade.

There is also a need for other nonliving marine resources. For example, available onshore reserves of sand and gravel in the Boston, Mass., New York City, and other eastern megalopolis areas are rapidly being depleted by a combination of heavy demands and land-use competition. Offshore reserves of these important commodities appear large enough to warrant major cooperative efforts of the coastal States, the sand and gravel industry, and Federal agencies to develop and extract them.

Also quite real is the prospect of mining such strategic minerals as manganese from the ocean floor. Investigations of deepwater dredging units and remote-sensing methods of discovering new mineral deposits are continuing. At the same time, there are strong efforts going forward to soften the impact of mining activities on marine life and the environment, and there is Federal emphasis on developing new freshwater supplies to meet the growing demands of coastal urban areas and industry.

Geologic Investigations and Mineral Resource Appraisal

Approximately 11 percent of domestic oil production now comes from wells on public lands of the Outer Continental Shelf, with output expected to increase to as much as 30 percent by 1980. During 1970, the value of this

production was close to $2 billion; since 1953, Federal revenues from offshore petroleum operations have exceeded $6 billion. Salt and sulphur are also being exploited from deposits beneath the Outer Continental Shelf, and the potential for production of other mineral commodities is favorable.

Metalliferous muds found in depressions on the floor of the Red Sea by Woods Hole Oceanographic Institution scientists in 1965 have been the object of repeated investigations. During 1971, studies were undertaken by a German combine and by scientists from Woods Hole and USGS. Results indicate greater thickness of the deposits than originally suggested and confirm earlier estimates of copper, zinc, silver, gold, and lead deposits, most of which may be recoverable if efficient mining techniques can be developed.

Of the identified potential mineral resources, the manganese nodules which cover vast areas of the deep ocean floor have attracted greatest interest because some deposits appear to contain large amounts of associated nickel, copper, and cobalt. Reports presented at a recent conference at Columbia University's Lamont-Doherty Geological Observatory included industry plans for the construction of prototype mining ships to test the economic feasibility of deep-sea mining and preliminary results of studies to determine environmental impact of planned operations.

In addition to the associated minerals, the sediments and rocks of the sea floor form the foundation for many species of marine life and for manmade structures. As on land, the foundation conditions may be stable or unstable and hazardous.

The USGS marine program emphasizes investigations, mapping, and analysis of the sea-floor geologic environment to aid in planning the most efficient use of the public lands; to outline and evaluate areas of potential mineral and energy resources, both regionally as part of the national resource inventory and locally in support of leasing operations conducted by the Bureau of Land Management; to delineate geologically hazardous areas where development may be detrimental or require special precautions; and to obtain knowledge of sea-floor processes and conditions that can be applied to the search for new mineral sources, such as unexploited deposits of sand.

In response to the President's intention to accelerate lease sales, studies will be made to delineate areas of the Outer Continental Shelf that have potential for petroleum resources. Existing geologic, geophysical, and engineering data are being acquired and synthesized to outline prospective resource areas. During 1972, a cooperative effort of the USGS and NOAA will begin field studies on parts of the Atlantic and south Alaska continental margins to obtain data for these areas not now available. The mapping effort associated with this work is described in chapter IV.

In a cooperative program of USGS and the States of Massachusetts and Maine, preliminary maps on bedrock geology and the distribution of sea-floor sediments, including deposits of sand and gravel, have been completed. Duke University scientists, under a USGS research contract, have compiled offshore data needed for a general land-sea geology map of the Cape Lookout region of North Carolina.

Within the Gulf of Mexico and Caribbean Sea region, geologists, geochemists, and other scientists of the USGS are currently engaged in the interpretation, analysis, and preparation of reports for samples and data

collected during joint programs with the Navy and Puerto Rican Government and, during IDOE cruises, with the University of Mexico and participants from other countries. Activities completed during 1971 included preliminary compilations of the geology south of Puerto Rico and of geophysical data for 15,000 miles of traverse in the Gulf of Mexico; reports on the geologic structure from south Texas to the Tabasco State of Mexico and on a large gravity anomaly beneath the central Florida shelf; and maps showing the geology and structure of the eastern Greater Antillean region and the geochemistry of bottom sediments on the northern shelf of the gulf.

Along the west coast, USGS studies and completed reports emphasize the location of faults and other structures beneath the ocean floor off California and Oregon, the heavy metal potential of sands off northern California, and the geochemical properties of sediments and sedimentation processes off northern California and Oregon. Some results represent products of research contracts with the Scripps Institution of Oceanography and the University of Oregon. Off Alaska, geologic and geophysical mapping during 1971 resulted in reports on the offshore petroleum potential of the Pacific Margin Tertiary Basin along the southern coast of the State, on structures of the Aleutian Bering Region, and the geology of the Chukchi Sea. The Chukchi Sea studies were jointly conducted by the USGS and the Coast Guard.

The current search for sand is focused offshore with the intent to explore and inventory deposits suitable for future beach-fill requirements and subsequently to develop and refine techniques for transferring offshore sand to the beach as a part of the Corps of Engineers' beach erosion control and shoreline hurricane protection program. A new program will begin this year in the Cape Fear area of North Carolina, and reports will be prepared for central and northern Florida, the New York Bight, Cape Cod Bay, and the entrance to the Chesapeake Bay. In Fiscal Year 1973, data will be collected off southern California between Santa Barbara and Los Angeles and reports will be completed for Long Island Sound, the south shore of Long Island, and Cape Fear.

Leasing and Management of Mineral and Petroleum Resources

Each major area of high petroleum and mineral potential that has been identified or is now being developed presents conditions that are unique or differ significantly from those of the other areas. Resource appraisal programs are, therefore, adjusted to meet the specific requirements in each area. Along the Gulf of Mexico and southern California coasts, offshore oilfields are extensions of, or similar to, those of adjacent land areas; the structures and nature of the geologic formations in which oil may be found can be predicted, most drilling conditions are known, and processing facilities are generally nearby. Along other coasts, however, the geological relations between onshore and offshore areas are less well known. Consequently, much greater effort is needed to evaluate the many factors that must be considered before lease sales permitting exploratory drilling are made.

Resource appraisals prepared by the USGS are submitted to the Bureau of Land Management, which has leasing responsibilities for Outer Continental Shelf lands. Using the appraisals, together with environmental and economic data supplied by other agencies, the Bureau of Land Management has begun the implementation of a 5-year accelerated lease-sale schedule for oil and gas to help alleviate the impending energy shortage. However, this leasing program has been delayed due to controversies over environmental issues. There also has been strong resistance to the proposed exploration of the east coast. As a basis for planning and managing future mineral development on the Outer Continental Shelf within the constraints of environmental protection, the Bureau plans to initiate intensive analyses of the effects of current and past mineral exploration, development, production, and transportation on other marine resources and uses and to begin analyses of environmental, economic, and sociological factors in areas of potential future mineral development.

In 1972, the USGS expects to be overseeing about 700 oil-, gas-, and sulfur-producing leases on the Outer Continental Shelf on which approximately 1,000 new exploratory and development wells will be drilled. The management program also includes maintenance of about 750 royalty production accounts and 725 royalty/rental accounts that should produce more than $400 million in Federal revenues. Analyses of geological conditions and engineering procedures before approval of proposed drilling for each of the 1,000 new wells are aimed at assuring adequate safeguards against blowouts and provide protection of the environment and other resources. Analyses are also being made of about 7,000 lessee proposals for items such as well spacing, well workovers and recompletions, equipment requirements, unitizations, and transportation allowances for royalty accounting purposes. A program to establish and monitor production rates for the Gulf of Mexico has also been initiated.

Marine Minerals Technology

The work of NOAA's Marine Minerals Technology Center in assessing the environmental impact of marine mining operations was noted in chapter II. This effort is a part of the larger program in improved mining technology which deals mainly with tools of the trade and with the problems of characterizing and monitoring marine mineral reserves. The region of primary interest here is in the first 10 to 50 feet of unconsolidated sediments on the ocean floor where bedded deposits, such as phosphorite and manganese nodules, and potentially rich submerged beach and stream channel placers may be found.

A continuing program seeks to determine the state of the art of bottom-sampling devices—piston corers and air-hammer drills—against the requirement for reliable, representative samples and various extractive techniques for subsea mining. The Tiburon, Calif., facility is also examining the marine potential of geophysical techniques used in land mining. One of these, an experimental directional multiple-seismic-sound source, has produced seismic-reflection profiles which show excellent quality and depth of penetration and is now being developed into a more complete prototype

system. Last year, a marine self-potential profiling unit showed good results in field tests. The instrument operates on the principle that some metallic ore bodies in the sea floor generate electric self-potential which can be detected as anomalies in surrounding sea water.

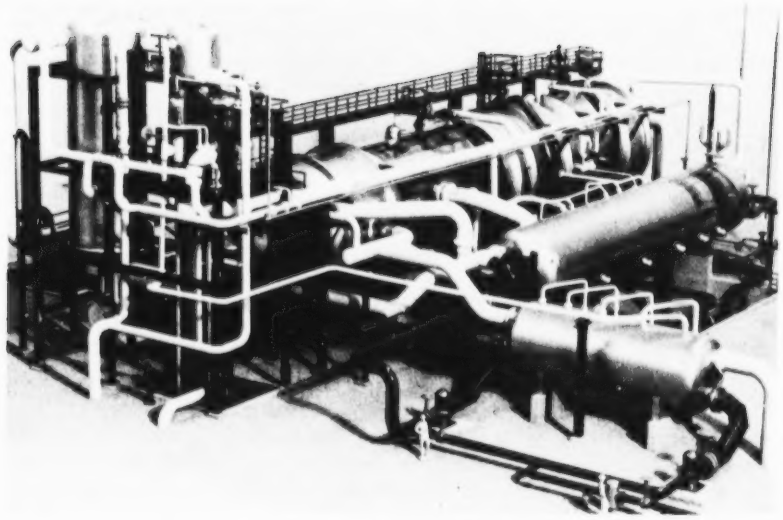
Mineral deposits themselves are the object of continuing studies at Tiburon where scientists are learning how to model the important characteristics and environments of such reserves. Parts of this effort have been moved out to sea, to actual deposits of unusual promise. For example, efforts were directed last year toward modeling blanket-type phosporite deposits off the Pacific coast, using underwater photography, geophysical and geological data, and laboratory analysis of drill samples taken off San Diego, Calif.

Water Resources

In 1971, USGS personnel completed a detailed analysis of circulation in Port Royal Sound, S.C.; undertook a joint investigation with the Corps of Engineers, State of Florida, and City of Tampa to determine the potential effects of proposed harbor dredging on subsurface aquifers which provide the city's water supplies; and showed that circulation and flushing of San Francisco Bay are dependent on the inflow of the Sacramento River. Additional continuing effort includes monitoring water discharge and quality in cooperation with all coastal States and research on salt-water intrusion, sediment transport and deposition, relation of streamflow to salinity, changes in dissolved constituents, tidal discharge, and the principles of estuarine hydraulics.

Such programs are important to the development and maintenance of fresh-water supplies for coastal communities and industry. The need for protecting and enhancing existing supplies has already become a pressing problem in some coastal areas, for example, parts of southern California, southeastern Texas, southern Puerto Rico, and the popular resort areas of southern Florida and the Virgin Islands. If current rates of development are to continue, the need for new sources will become critical. The demand for fresh water in coastal regions over the past 5 years has been increasing by about 10,000 gallons per minute each day. From population trends and water-use practices, it is estimated that the United States will be required to more than double existing fresh-water supplies during the next 15 years.

With the feasibility of desalting sea water established, the Office of Saline Water conducts and supports research to develop materials, equipment, and technology for the separation and purification of freshwater from sea water in large quantities at low cost; determine potential environmental effects of operating desalting plants and disposal of waste brines; and evaluate possible mineral recovery from concentrated brines. Developments during the past year have included advances in materials and in corrosion and process controls that may result in substantial cost reductions for future operations. A module-type 3-million-gallon-per-day desalting plant being built in Orange County, Calif., is scheduled for completion in late 1972 and will serve as the basic element of a planned 200-million-gallon-per-day plant to meet future critical demands of nearby communities and agricultural areas.



The water resource of the global ocean is being tapped for human and industrial consumption as technology permits. The 3-million-gallon-per-day desalting plant being built in California's Orange County is shown here in mockup.

International Activities

Today, as new technologies of harvest and converging human needs intensify competition between nations, international contact and cooperation become more and more the road individual nations must take to solve their marine resource problems.

During 1971, the United States pursued resource-related national objectives on a number of international fronts, and, as noted in chapter II, continued work toward the United Nations Conference on the Human Environment, the Law of the Sea Conference, and the IMCO Conference on Marine Pollution. The United States also continued participation in the work of nine international fisheries commissions.

At the Geneva, Switzerland, summer session of the United Nations Seabed Committee preparing for the Law of the Sea Conference, the United States submitted draft articles on the breadth of the territorial sea, straits transit, and fisheries. It was proposed that a maximum breadth of 12 nautical miles be established for the territorial sea, conditioned upon agreement on a right of free transit through and over international straits. Concerning fisheries beyond a 12-mile territorial sea, it was proposed that high seas fisheries be regulated by international (including regional) fisheries organizations established or to be established for this purpose. A coastal State would be given a preference based on its actual fishing capacity; such preference to be expanded as its capacity expands. On traditional fisheries, the U.S. draft envisioned further negotiation on an appropriate text. Highly migratory fish would be excluded from coastal State preferences. The implementing regulations of the coastal State would apply in any area of the high-seas

adjacent to its coast or, with respect to an anadromous stock that spawns in its fresh waters, throughout its migratory range. The U.S. representative indicated the basic flexibility of the U.S. position on management of seabeds and ocean resources so long as certain principles were included.

The United Nations General Assembly reviewed the progress of the preparatory meetings, expanded the Seabed Committee by adding the People's Republic of China, Finland, Fiji, Nicaragua, and Zambia, and scheduled two meetings for 1972, one in March in New York City and one in July and August in Geneva.

Fishery Arrangements

The 15-member-nation International Commission for the Northwest Atlantic Fisheries (ICNAF) started international enforcement of fisheries regulations on July 1, 1971, under which enforcement officers may, on the high seas, board and inspect fishing vessels from any of the member nations. The ICNAF inspection system has been operating smoothly. In December 1971, for example, U.S. inspectors boarded three Soviet trawlers and found no violations of ICNAF regulations. The Soviets inspected two American fishing vessels. The procedure is virtually identical to one used under the North-East Atlantic Fisheries Commission (NEAFC). The United States and Poland agreed in 1972 to an enforcement plan for the mid-Atlantic area. Thus, United States, Canada, Japan, the Soviet Union, and virtually every other nation fishing the North Atlantic participate in a mutual policing system. Similar agreements have been in force in the North Pacific for many years. These projects lay the groundwork for international cooperation in the enforcement of other multilateral agreements.

In late 1971, an amendment to the ICNAF Convention, which will add economic and technical considerations to serve as a basis for fisheries regulations, became effective. Traditionally, ICNAF rules have been based only on scientific criteria. This amendment will permit ICNAF, in the formulation of regulations, to consider the latest developments in fishing vessels and techniques and the economic problems faced by coastal fishermen competing with large, mobile fleets of factory trawlers. This means that the Commission will be able to apportion the catch among nations. For example, small-boat American fishermen, who are competitively at a disadvantage with highly mobile foreign fleets operating off our coasts, would have an equitable portion of the catch reserved for them.

With respect to Atlantic salmon, no general agreement has been reached among the North Atlantic fishing nations to reduce further the wasteful high-seas fishing of that species. However, the United States and Canada issued a joint policy statement reaffirming their intention to continue their efforts to achieve the elimination of the high-seas fishery which threatens the existence of one of the world's great natural resources. An important step in this direction was taken on February 24, 1972, with the announced agreement between the United States and Denmark to curtail Danish high-seas salmon fishing off West Greenland.

Under the agreement, the high-seas fishery by Danish flag vessels will be gradually phased out over a 4-year period, 1972 through 1975. In addition,

the inshore salmon catch by local Greenland fishermen will not be increased over the average level of recent years. The agreement serves the interests of such countries as the United States and Canada which undertake heavy expenditures to protect salmon runs in the streams of origin. It also serves those of Denmark by considering the special importance of the local salmon fishery to the economy of Greenland.

Denmark and the United States will seek to have the essentials of their agreement incorporated in the conservation regulations of ICNAF at its annual meeting in May 1972. ICNAF has already adopted a ban on high-seas salmon fishing effective for 12 nations and interim measures on other aspects of the salmon fishery in the Northwest Atlantic.

In addition to conservation measures, 1971 was marked by a high degree of success in resolving conflicts over fishery resources. A new and potentially serious problem appeared in the spring of 1971 when the operations of foreign trawlers resulted in large-scale destruction of lobster pots in the developing American deepwater lobster fishery off the North Atlantic coast. Prompt action by the Department of State, the Coast Guard, and NOAA, and the full cooperation of American fishermen and foreign fisheries authorities brought the problem under control. The State Department helped the American fishermen recover damages for their lobster pot losses.

In the North Pacific, the United States continued its participation in the International North Pacific Fisheries Commission. In addition, voluntary cooperation of other nations with regard to high-seas salmon fishing helped to conserve this valuable resource more effectively. International agreements reached earlier resulted in minimizing gear conflicts in the king crab and halibut fisheries.

Agreements with the Soviet Union regarding North Pacific fisheries were reviewed in 1971 and new versions providing additional protection for American coastal fishermen and improved measures for conservation of the fish stocks were signed. In addition, the United States and Soviet Union agreed to broaden their Mid-Atlantic Fisheries Agreement to include river herring, a species of interest to American sports and commercial fishermen. Final agreement had not been reached on this species in the earlier renegotiation in late 1970.

United States distant-water tuna and shrimp operations have in recent years been among the most profitable sectors of our fishing industry. In 1971, these fisheries continued to be plagued by problems arising out of the unsettled status of international law on breadth of the territorial sea and the extent of coastal State fishery jurisdiction (see appendix E). In 1971, 51 U.S. tuna ships were seized by Ecuador while operating off the Pacific coast of Latin America. Nearly $2.5 million in fines were paid. The tuna-boat seizures by Ecuador in the early months of 1971 produced reactions by the United States, particularly a suspension of military equipment sales, and counterreactions by Ecuador, notably an accusation of "economic coercion" against the United States in the Organization of American States (OAS), making it impossible to hold the scheduled quadripartite conference between Chile, Ecuador, Peru, and the United States to consider this problem. Diplomatic efforts to achieve even a temporary solution continued actively but have not been successful.

Tuna, the third most valuable U.S. catch, are the object of intensive fisheries research. The school shown here was photographed from an underwater viewing port on the NOAA ship Townsend Cromwell *on a tuna expedition in the Pacific.*

The conservation system of the Inter-American Tropical Tuna Commission, which has had the yellowfin tuna of the eastern Pacific under a catch limitation since 1966, continued to maintain the resource at a high level of abundance, but faced severe strains over the problem of providing equitable opportunities for the growing fleets of the United States and other nations.

In the Atlantic, as the International Commission for Conservation of Atlantic Tunas moved into its second year of operation, the conservation requirements of Atlantic tuna stocks became more sharply focused. Brazil acted to implement the fishery jurisdiction claimed in its 200-mile territorial sea proclamation of the previous year. This alarmed the operators of the large U.S. flag shrimp-trawler fleet fishing the Brazilian coast from bases in Guyana, Trinidad, Surinam, and French Guiana. It also caused concern to the Governments of these countries where shrimp processing and exporting is of economic significance. In October, United States and Brazilian delegations met at Brazilia for a week of preliminary talks to explore ways of mutual accommodation in the shrimp resources of northeastern South America and to avoid a confrontation on the jurisdictional issue. The views of the two Governments were thoroughly aired and further talks on the subject held early in 1972 produced the text of an agreement.

The living resource and seabed assessment programs of the IDOE are described in chapter VI.

Chapter IV

MONITORING, PREDICTING, AND MAPPING THE OCEANS

Describing and predicting conditions in the marine environment are prerequisites to its safe and rational use, whether as a hunting preserve, laboratory, highway, or recreation area. Marine weather and climate, the "weather" and "climate" within the sea, navigable waters and navigation hazards, shore boundaries, the contours and content of the continental rim—all of these must be known.

As national objectives in the oceans crystallize into programs, the need grows for descriptions of greater detail, for prediction of longer duration and greater accuracy, and for innovative information management techniques to handle vast accumulations of data. The trend in the Federal Ocean Program is toward national and international systems that are increasingly capable of monitoring and predicting natural events and toward mapping and charting programs that are increasingly responsive to national needs. Behind this trend are a new family of multiple-use platforms, ranging from earth-orbiting satellites and their remote sensing capability to ocean data buoys capable of monitoring environmental processes in virtually real time.

Oceanic Observation and Prediction

Technological advances have significantly improved the abilities of marine scientists to extend their knowledge of oceanic properties and processes. But these advances in marine research have not been easily translated into new environmental services. To close this gap between what is available and what is needed, the Federal Ocean Program has grouped its marine observational and predictive efforts in MAREP (Marine Environmental Prediction), which identifies the systems approach to present and projected services. Represented on a committee under a Federal Coordinator from NOAA are the Departments of Commerce, Defense, the Interior, State, and Transportation, the AEC, EPA, NASA, NSF, and Smithsonian Institution. The MAREP objective is to make what has been diverse, coherent,

The hurricane-tracking capability of earth-orbiting satellites is pointed up by this photograph from NASA's geostationary Applications Technology Satellite (ATS) 3, which shows hurricane Edith (weakened over Yucatan), Fern (crossing the Texas-Mexico coast), and Ginger (in the Atlantic east of Florida) in September 1971. Photo gridding is by NOAA's National Environmental Satellite Service.

and to apply new knowledge and technology to improving the total national MAREP system.

In February 1971, the Federal Coordinator issued a *Federal Plan for Marine Environmental Prediction, Fiscal Year 1972*. This first full description of what America has in the way of MAREP services, what is under development, and what will be needed in the near and middle-distant future laid a framework for the further development of predictive services.

Specific objectives of the MAREP plan include development of: An integrated environmental monitoring system that will fulfill the need for physical and biological data from the oceans and their boundary regions and for predictive service programs, including those for control of pollution; integrated marine prediction and information services that include timely reports, forecasts, and warnings of natural and manmade hazards on the high seas, in coastal waters, and on the Great Lakes; and methods that assess and predict the abundance and distribution of the ocean's living resources. Although these exist in some form now, MAREP will endeavor to advance them to the very threshold state of their respective arts.

Today, a broad range of civil services are available. NOAA's prediction of sea and swell, storm surge and seiche, tropical and extratropical storm tides and tidal currents and the Corps of Engineers' channel and harbor activities do much to support marine navigation. The USGS water-quality stations, the Coast Guard expanding coastal-zone monitoring activities, and NOAA research into the dynamics of estuaries advance the fight against water pollution. The seasonal and short-term forecasts of fisheries abundance issued by the NOAA National Marine Fisheries Service aid fishermen and the managers of America's fishery resources. MARMAP (Marine Resources Monitoring, Assessment, and Prediction), described in chapter III, represents a kind of predictive subsystem of MAREP which should lead to a comprehensive view of the locations, populations, and relative abundances of the ocean's living resources.

A permanent network of tide gages is operated along the coasts and within the major embayments of the United States, Puerto Rico, other territories and possessions, and the U.S. Trust Territory of the Pacific Islands. There is also a water-level monitoring network on the Great Lakes. In addition, 150 temporary secondary stations were occupied during hydrographic surveys in 1971 to increase the coverage. In the next year, tide and tidal current predictions will be improved through the automation of 50 coastal stations.

The Pacific Tsunami Warning System, headquartered in Honolulu, Hawaii, and the Regional Tsunami Warning System at Palmer, Alaska, use data from a network of seismograph and tide stations around the Pacific Ocean Basin to generate timely warnings of destructive earthquake-generated tsunamis ("tidal waves"). During 1971, the warning network was strengthened by the addition of six seismograph stations and one tide station. No oceanwide tsunamis occurred last year, although tsunami watches were issued following large earthquakes centered in the New Guinea-Solomon Islands, Alaska, and Kamchatka, U.S.S.R., areas. A regional tsunami watch was issued by Palmer Observatory following *Cannikin,* the AEC's underground test on Amchitka Island, but no measurable tsunami action was observed. Plans continue against the time when the operational

geostationary satellite relay capability can be used in tsunami detection and warning operations.

A program is now underway to develop automated techniques for producing marine environmental forecasts. Work is proceeding on an improved method of wind forecasting for application to wave forecasting over oceanic areas. A wave climatology was compiled for the Great Lakes. The numerical model SPLASH (Special Program to List Amplitudes of Surges from Hurricanes) was developed for forecasting the hurricane storm surges along the U.S. Gulf and Atlantic coasts and entered experimental use at the National Hurricane Center.

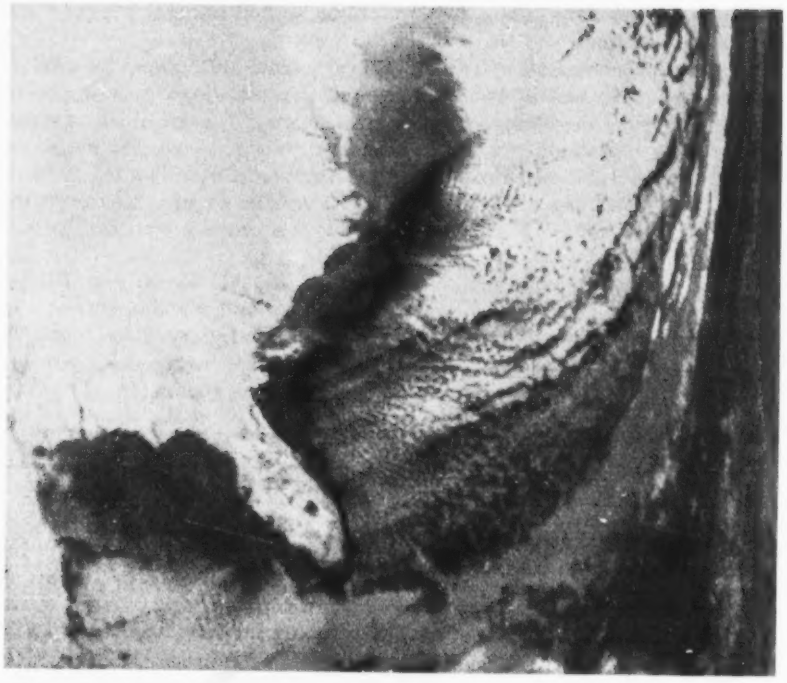
Wind-forecast techniques for Lakes Superior, Michigan, and Huron, presently under development, will be completed and made operational in 1973, and wave-forecasting techniques for the Great Lakes will be developed and implemented. Further improvements are planned for the hurricane storm-surge forecasting model, and studies are being conducted on breaker forecasting and hazardous-wave conditions over bars at the mouth of the Columbia River.

Increased efforts in satellite observation of large-scale synoptic weather patterns over oceanic areas are adding substantially to the forecaster's information on atmospheric conditions and thus enhance the prediction of oceanic storms. For example, the importance of geostationary satellites for hurricane warnings was proven last year in a number of instances, including the successful forecast of Hurricane Edith which struck the Louisiana coast. Critical data supplied by the satellites were instrumental in drastically reducing loss of life.

NOAA and NASA are also developing techniques for using satellite observational data in marine monitoring and prediction (see chapter VI). A histogram technique developed to derive sea-surface temperature from satellite infrared data was used last year to generate experimental surface-temperature maps. The technique has been applied to produce special temperature charts over small areas of particular significance to fishery and oceanographic investigations. Techniques for mapping sea ice, developed for use with satellite picture data, are being extended for use with satellite infrared data.

The expansion of the satellite observation program will include developing applications of very high resolution and multispectral data from new satellite sensors planned for orbiting spacecraft in 1972 and 1973. These sensors offer new possibilities for cloud filtering to obtain higher resolution mapping of surface temperatures and ice on seas and lakes. The new data will be applied to the detection and monitoring of oceanographic and coastal phenomena such as shoreline changes caused by storm action, shoal areas, sediment and pollution transport, and possibly evidence of marine biological processes of significance to fisheries and water-quality studies.

The Departments of Commerce, Defense, and Transportation cooperate in the monitoring and prediction of ice coverage and movement in the Great Lakes as well as in the Arctic Ocean off the North Slope, in Cook Inlet, and in other Alaskan waters. An interagency group, established under the lead of the Corps of Engineers, plans to demonstrate the feasibility of extending the navigation season on the Great Lakes (see chapter VI). These efforts should also improve prediction capabilities for snow, ice, and ice fog.



An inflared image from the ITOS–1 satellite taken 0900 G.M.T. March 1971. The darker tones represent the warmer waters of the Gulf Stream and reveal a number of eddies along the stream's boundary.

The National Data Buoy Project, managed by the NOAA National Data Buoy Center, is developing a system of buoys equipped with sensors to measure ocean and atmospheric environmental parameters, linked through telemetry to earth satellite and shore stations. The buoys are planned as unmanned automatic stations which can satisfy data needs for operational and research purposes. The U.S. Coast Guard provides personnel, vessel, and communications support to the National Data Buoy Project.

During 1971, the Center made significant progress in its program to carry buoy and sensor technology to engineering development and prototype deployment. Six Engineering Experimental Phase (EEP) discus buoy prototypes were procured under contract as were the first experimental prototype platforms (in the form of a deep-keel buoy) and prototype sensors. Competitive experimental designs of limited capability drifting and moored buoys systems were also obtained. The XERB–1 (Experimental Environmental Reporting Buoy), a 40-foot diameter discus type, completed its first year on station off Cape Hatteras, N.C., where it has been reporting environmental data in near real time.

In the next year, the Center will continue planning for developments and for participation in such scientific programs as the Global Atmospheric

The first of a series of six EEP buoys being readied for stationing in the summer of 1972. These 100-ton platforms, designed to withstand 150-knot winds, 60-foot waves and 10-knot currents, will be anchored in almost two miles of water 225 miles from Gulfport, Mississippi and can carry more than 100 sensors to measure and report oceanic and atmospheric conditions.

Research Program (GARP) Atlantic Tropical Experiment (GATE), the Arctic Ice Dynamics Joint Experiment (AIDJEX), and the Mid-Ocean Dynamics Experiment (MODE) of the IDOE (see chapter VI). This participation will provide operational experience for buoy technology developed thus far. As presently planned, the data buoy program will begin a 2-year test and evaluation of EEP buoys in the Gulf of Mexico during the summer of 1972, deploy experimental prototype limited-capability buoys in the Gulf of Mexico during the fall of 1972, add advanced technology components for test and evaluation in the summer of 1973, enter engineering development of a pilot buoy network in the summer of 1974, and begin operation of a pilot buoy network in the summer of 1976.

The National Oceanographic Instrumentation Center (NOIC) serves as a national center for test and evaluation of newly developed oceanographic instruments and for calibration of operational instrumentation. Organized within the Navy's Hydrographic Office in the 1950's, it was formally established by the Secretary of the Navy as a national center in 1960, became a full-fledged national center in 1969, and transferred to NOAA in October 1970 under Reorganization Plan No. 4.

The current NOIC program centers on precise simulations of the ocean environment to test and evaluate the multiplicity of instruments being developed for marine science applications. The NOIC Washington Navy Yard facility includes tanks, flumes, and pressure chambers, with precise control, test, and measurement equipment.

Instrument calibration work for the International Field Year of the Great Lakes (IFYGL) will continue through 1973. Also, a Gulf Coast Regional Center in the NASA Bay St. Louis, Miss., complex will come into operation and provide instrument calibration services for the experimental buoy deployment in the Gulf of Mexico as part of the National Data Buoy Project. A Pacific Northwest Calibration Facility in Seattle is being planned under a cooperative program between NOAA and the State of Washington. Both the Bay St. Louis and Seattle activities will serve as Regional Calibration Centers, providing rapid and economical calibration services to local area users.

Military users also depend upon civilian observational services for support, but their worldwide scope of operations often creates demands beyond these. To meet their special requirements, the Navy operates a substantial marine observational program with ships and aircraft. This program, while conducted primarily to fulfill military requirements, provides selected observational data to other agencies.

Although the Department of Defense operates a large subsurface synoptic oceanographic net, mostly in the Northern Hemisphere, high-quality observations are insufficient from most ocean areas. To correct this, selected commercial and naval ships have been equipped to make additional observations, and improvements are constantly being made in instrumentation. In recent years, the Navy has introduced new and more precise devices—for example, Near-Surface Reference Temperature (NSRT) devices and Airborne and Surface Expendable Bathythermograph (AXBT and SXBT) equipment—to provide higher quality data. As more naval and civil vessels participate, data coverage will be improved. Approximately 70 civil, fishery,

and research ships were equipped with expendable bathythermographs in the Navy's Ships of Opportunity Program as of January 1, 1972, with more being outfitted during Calendar Year 1972.

Prediction of the properties and dynamics of major eddies in the western North Atlantic is now considered feasible. Surveillance and tracking of both warm and cold eddies as a routine operational procedure for periods up to 6 months are leading to a much improved understanding of these phenomena. Such forecasts will have many significant applications, including those to fisheries because much of the contained sea life restricts its movements to the eddy cell.

An Evolving Global System

Among the important elements of the Federal Ocean Program's observational activities are those looking to a global environmental monitoring system. To this end, the Federal Government has mounted an intensive technological effort aimed at providing the essential ocean-stationed sensors and platforms and ocean-monitoring instruments for satellites.

The Integrated Global Ocean Station System (IGOSS) is a major marine monitoring and prediction program initiated by the Intergovernmental Oceanographic Commission (IOC) with the collaboration of the World Meteorological Organization (WMO). The purpose of IGOSS is to bring together a number of national systems to form, ultimately, a dynamic worldwide system for observing and measuring the marine environment. The initial pilot program for collection, exchange, and evaluation of bathythermograph data began early in 1972, using high-speed telecommunications systems set up under United Nations agreements, principally the Global Telecommunications System of the WMO World Weather Watch. The national data buoy system, and its related satellite relay systems, will be a major contributor to IGOSS.

Mapping and Charting the Oceans

The traditional cartographic description of the marine environment has been the navigation chart, which continues to represent a large portion of Federal mapping and charting activity. But emphasis has expanded here as well as in other categories of activity, and Federal agencies have turned to the task of providing bathymetric and geophysical depictions of continental and shelf-lands, large-scale coastal zone maps, and seaward extension of geodetic control. In particular, the Federal Ocean Program is now committed to reconnaissance map the bathymetry, geophysical character, and resources of our Continental Shelf. There is also emphasis on applying new technologies to improved and automated hydrographic and cartographic operations.

Nautical Charts

The Departments of Commerce and Defense are the Nation's principal chartmakers: NOAA producing nautical charts of the United States and its possessions primarily for marine transportation, recreational boating, and

national defense; and Navy producing charts directed more to meeting the needs of global defense operations, although these products are largely available for civilian use.

NOAA's nautical charting program includes conventional nautical charts, small-craft charts, and Great Lakes charts, and such supplementary publications as Coast Pilots, Lake Pilots, Tide and Current Tables, and other products relating to the waters of the United States and its possessions. NOAA now publishes a total of 825 nautical charts, of which 78 are especially designed for the recreational boater. In 1971, 479 of these charts were revised and updated and three new charts were issued. Ships and field parties conducted extensive hydrographic and oceanographic surveys in support of the nautical charting program along the coasts of Alaska, California, Hawaii, North Carolina, South Carolina, Florida, Puerto Rico, and American Samoa as well as in Delaware Bay, Massachusetts Bay, and Oregon's Umpqua River. Special surveys were performed between Florida and the Bahamas and in the Gulf of Maine. Other surveys included wire drag surveys of Gulf of Mexico sealanes and the entrance to Delaware Bay; and tidal current surveys in the Charleston, S.C., and Boston, Mass., Harbors.

During Fiscal Year 1973, NOAA plans to continue these hydrographic operations along the coasts of Alaska, California, Hawaii, South Carolina, Puerto Rico, and in Delaware Bay. Wire drag surveys of safety fairways and separation lanes on the Gulf of Mexico and around major east coast ports will continue, and circulatory surveys in the Port Royal Sound and Savannah

Nine ships of NOAA's fleet gathered at their Pacific Marine Center base in Seattle, Washington. Clockwise from bottom left: Surveyor, Oceanographer, Fairweather, Davidson, Milton Freeman, McArthur, Kelez, Rainier, *and* Pathfinder.

River area, S.C., Portland, Maine, and Cape Cod Bay, Mass., will be initiated.

Other elements in NOAA's nautical charting program include technical assistance to other organizations and governments, a cooperative charting program with the USCG Auxiliary and the U.S. Power Squadrons to obtain volunteer citizen aid in maintaining up-to-date charts, contributions to Navy and Coast Guard *Notice to Mariners* programs, inputs to Corps of Engineers harbor-approach programs, and liaison with the Canadian Hydrographic Office and the International Hydrographic Organization (IHO). NOAA and the Navy are members of the IHO and participate in establishing international hydrographic standards.

Navy charting efforts are almost totally directed to open oceans and operational needs and, in cooperation with the hydrographic offices of host nations, foreign coasts. However, some special efforts in 1971 deserve mention here. Navy accepted delivery of two large new coastal hydrographic survey ships, USNS *Chauvenet* and USNS *Harkness*. Ship trials and tests of survey systems were conducted in areas of interest to NOAA and produced more than 16,000 miles of soundings off the Virginia and North Carolina coasts. In addition, the Navy survey effort includes a development program which, in 1971, demonstrated successful sounding operations at 25 knots by a 36-foot launch, successfully flight-tested a helicopter pod containing a television-sight cartographic camera system, and fabricated a prototype mooring for its offshore electronic navigation aid station.

Geophysical Mapping

The Departments of Commerce, the Interior, and Defense are the major contributors to the Federal geophysical mapping program. NOAA provides reconnaissance bathymetric and geophysical maps of the Continental Shelf and Slope of the United States. In addition, its Scientific Exploration and Mapping Program (SEAMAP) provides geophysical mapping in the deep ocean areas. The USGS conducts detailed geologic mapping and geophysical analysis of the geologic structure of the continental margins. These complementary NOAA and USGS continental-margin programs provide data for use in potential mineral resource investigations and appraisals and baseline information for coastal zone management. The Navy defense-oriented deep-ocean geophysical surveys also furnish data useful in these programs.

NOAA's marine geophysical mapping program provides a comprehensive description of the general geophysical properties of the ocean bottom and substructures as well as producing data needed for a better understanding of ocean properties and processes. The measurements include bathymetry, gravity, magnetism, seismic profiles, heat flow, sediment cores, and physical oceanographic parameters.

Last year, the newly commissioned NOAA Ship *Researcher* performed geophysical research in the Caribbean Sea and the Gulf of Mexico in support of CICAR (Cooperative Investigation of the Caribbean and Adjacent Regions). The *Surveyor* accomplished geophysical studies in the south-central Pacific and off the Washington-Oregon coasts as part of SEAMAP, sponsored in part by NSF under the IDOE program (see chapter VI).

Bathymetry and seismic refraction profile surveys of the North Carolina coast and gravity surveys of the west coast Continental Shelf were also conducted.

Special geological and geophysical studies were made between Cape Hatteras and Cap Blanc, Mauritania, in support of the Trans-Atlantic Geotraverse (TAG), a seaward extension of the U.S. Transcontinental Geophysical Survey, and will provide a continuous crustal section completely across a continent and an ocean basin. The TAG corridor is an approximate 200-mile-wide band between Cape Hatteras and Cap Blanc. In addition, surveys were conducted in the Juan de Fuca Fracture Zone area to determine changes in magnetic characteristics.

In the Navy, more resources are dedicated to deep ocean bathymetry and geophysical data collection than to any other component of its survey program. The high-priority areas which these surveys primarily support, strategic forces and antisubmarine warfare (ASW), are global in extent. In 1971, over 500,000 track miles of precise bathymetric data, 250,000 miles of shipboard gravity and geomagnetic data, and 150,000 miles of subbottom seismic reflection profiling data were collected. This was augmented by almost 100,000 track miles of airborne geomagnetic survey data collected to define the residual magnetic anomaly field in support of ASW. The Navy's effort is receiving increased emphasis in 1972 through the replacement of older ships and aircraft and the diversion of other ships to assist in such surveys.

Coastal Zone Mapping

The coastal zone mapping effort includes metric aerial photography; surveying and mapping for control of hydrography and maintenance of topographic chart details, location of landmarks, and aids to navigation; surveys to delineate coastal inundation limits, coastal boundaries, and storm evacuation routes; and advisory and technical services to States engaged in implementing a coastal zone wetlands mapping program. There is also some effort here to extend geodetic control seaward.

Over 17,000 lineal miles of panchromatic, infrared, and color aerial mapping photography were flown in 1971, using wide-angle and super-wide-angle single-lens precision cameras. About 120 shoreline maps and related photogrammetric data were provided to support hydrography. A total of 330 charts and basic map drawings were corrected from new aerial photography, including the compilation of topography for small-craft charts and the location and verification of about 600 aids to navigation and 400 landmarks.

Federal, State, and private boundaries in the coastal zone must be determined for the proper planning and management of the coastal zone environment. In coastal areas, the mean high-water line usually marks the boundary between State and private ownership; the mean low-water lines on the east and west coasts define the baseline from which seaward jurisdictional boundaries are delineated, as, for example, the seaward boundary between Federal and State jurisdiction over seabed resources. The equiva-

lent of 46 of the planned 400 boundary maps of Florida have been completed under a cooperative Florida and NOAA program to map the shore and seaward boundaries. In cooperation with the Mexican Government, a seaward-boundary survey was completed in 1971 to determine and fix the seaward-lateral boundaries between the United States and Mexico in the Gulf of Mexico and on the Pacific coast.

As part of the National Flood Insurance Program administered by the Department of Housing and Urban Development, the Corps of Engineers, NOAA, and the USGS are providing mapping, hydrologic, and associated technical information and services for the proper management of flood losses in the coastal zone. Studies and maps were recently completed for areas in Alaska, California, Florida, Louisiana, Massachusetts, New Jersey, New York, North Carolina, South Carolina, Texas, and Virginia.

A storm-evacuation mapping program was instituted to provide a series of maps for flood-prone areas along the Atlantic and Gulf coasts where hurricanes may strike. These special maps depict evacuation routes, areas subject to flooding, and elevations that might afford "safety islands" for evacuees. The first maps of the coastal areas from Mobile, Ala., to New Orleans, La., were completed in 1971.

A program in marine geodesy is being planned to extend the land geodetic net onto the continental shelves for precise control and for studies regarding land movement on the west coast Continental Shelf. Of special interest here is NASA's investigation of possible application of geodetic satellite technology and related precision-ranging techniques to marine geodesy (see chapter VI).

Automation of Data Acquisition, Processing, and Reduction

In Fiscal Year 1971, NOAA initiated the development of automated techniques for its nautical charting. Initial emphasis has been on data acquisition, data processing, and nautical chart compilation. Upon completion of the program, estimated to take 5 years, all nautical chart production will be automated and the time lapse from the completion of data acquisition to the dissemination of nautical charts will be reduced from 2 years to 6 months.

Major accomplishments to date include installation of automated data-acquisition equipment aboard three vessels assigned to the coastal charting program; increased staffs for hydrographic survey verification and evaluation dedicated to a reduction of the present unqualified hydrographic survey backlog; initiation of the digitization of the 2,700 hydrographic surveys comprising the present marine chart data base of qualified hydrographic surveys; procurement of a computer-supported graphic-digitizing system to support the automated compilation effort; and upgrading of the present data processing system at the Atlantic Marine Center to increase speed, efficiency, and production volume.

Close liaison between the Naval Oceanographic Office, the U.S. Army Topographic Command, Rome Air Development Center, the Canadian Hydrographic Service, and NOAA is being maintained to insure a mutually beneficial development program.

Ocean Information Services

The increasing quantities of environmental and biological data being acquired by Federal programs have led to strong emphasis on improving data management concepts and equipment. NOAA's Environmental Data Service and its associated World Data Centers are the national focus for this effort.

The Environmental Data Service comprises the National Oceanographic Data Center (NODC), National Climatic Center (NCC), National Geophysical Data Center (NGDC), Aeronomy and Space Data Center, Environmental Science Information Center, and the Laboratory for Environmental Data Research. Several Data Centers have collocated World Data Center subcenters, including World Data Center A, Oceanography. All marine geophysical data, formerly held by NODC, were turned over to the NGDC in 1971. NODC continues to be responsible for all other forms of oceanographic data and for the National Marine Data Inventory (NAMDI).

The Environmental Data Service has established a Great Lakes special project group within NODC. This group, to be relocated to Detroit, will plan and eventually establish a central NOAA repository for environmental data associated with the Great Lakes and is active in the International Field Year for the Great Lakes (IFYGL).

Approximately 85 percent of NOAA's data customers are non-NOAA scientists from home and abroad, other Federal agencies, industry, and the general public. In 1971, considerable progress was made in the consolidation and automation of marine data and information services; the development of a necessary central reference system, ENDEX (Environmental Data Index) and OASIS (Oceanic and Atmospheric Scientific Information System); and such national and international programs as the Barbados Oceanographic and Meteorological Analysis Project (BOMAP) and the International Decade of Ocean Exploration (IDOE). In addition, NOAA is actively strengthening interagency coordination and cooperation in the environmental sciences through bilateral and multilateral agreements and arrangements with other agencies, including the Corps of Engineers, EPA, NSF, and the Smithsonian Institution.

NOAA and EPA began a cooperative pilot project to combine EPA research information and monitoring data with NOAA's Environmental Data Service data inventories and bibliographic reference in a single "browse-oriented" information retrieval system. Reference files for oceanographic and meteorological data and literature for the the New York Bight area were loaded into the information retrieval system of the EPA Water Quality Office. The two agencies are also working toward establishing mechanisms for the exchange of data and information between NODC and the EPA STORET (storage and retrieval) data file. These interactions will support and complement the NOAA–EPA oceanic and coastal zone marine-pollution data exchange.

In February 1971, a temporary data archive was established to service user requests for some 26 processed data products resulting from the Barbados Oceanographic and Meteorological Experiment (BOMEX). The

temporary archive consists of preliminary, unvalidated data and will be replaced by a permanent archive as the BOMEX data-processing cycle is completed.

During 1971, NSF designated and funded NOAA as lead agency for data management and information services for all U.S. IDOE programs. Three data centers—NODC, NGDC, and NCC—are involved in the acquisition, formating, storage, and dissemination of IDOE oceanographic, geophysical, and meteorological data. These Centers are examining IDOE project proposals to insure that adequate attention is given to data handling and documentation.

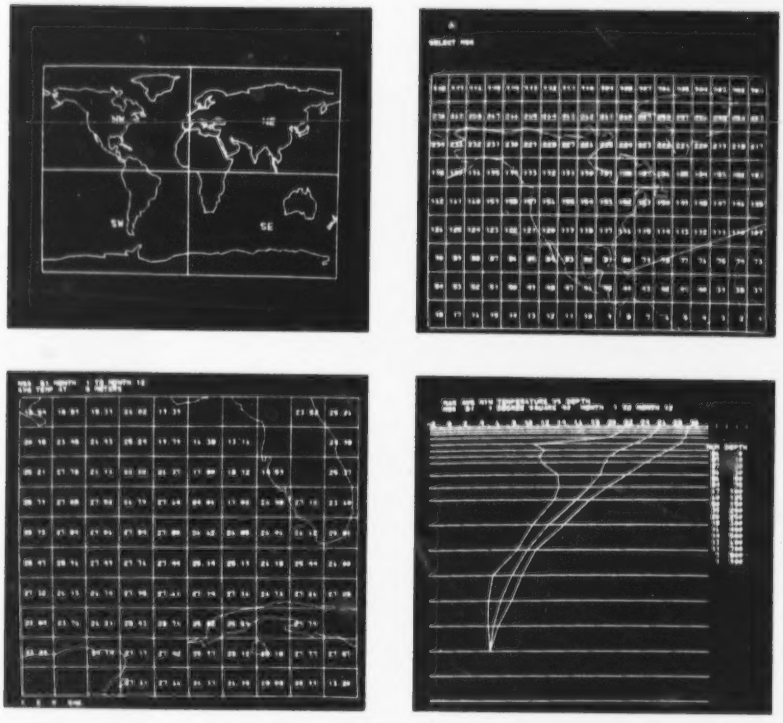
NODC took the first step last year to implement its "live atlas". The system involves the direct interaction of marine data users with the NODC data base through the use of a cathode ray tube (CRT) display station. Requests are made to the computer for various oceanographic parameters by season, time, and depth; the data requested are displayed on the CRT in tabular or graphic form; and hard copies can also be produced. The initial data base was limited to data from the eastern Gulf of Mexico but has since been expanded to cover U.S. coastal waters from Maine to Alaska. Consideration is being given to the installation of remote terminals in other agencies and activities to allow direct interaction with NODC.

In cooperation with UNESCO and the Secretariat of the IOC, an AID-sponsored training program was established under NODC's leadership in June 1971. Its purpose is to assist developing countries in Africa, Asia, and Latin America to strengthen their programs and capabilities in marine data collection, processing, and application. Each training class (two have been completed, the third will begin in May 1972) is selected by NODC and the IOC Secretariat. The overall program includes lectures, seminars, and fieldwork in a number of Federal and academic institutions including the Woods Hole Oceanographic Institution and the University of Rhode Island International Center for Marine Resources Development.

An NODC computer-produced *Atlas of Selected Environmental Variables off the Coastal United States,* started in 1971, is scheduled for completion in 1972. The NODC is also cooperating in the preparation of the ICITA (International Cooperative Investigations of the Tropical Atlantic) atlas to be published by the IOC and the CIGAR bibliography.

The NCC established a magnetic-tape surface-marine meteorological observations file containing 31 million entries by consolidating 17 data sources into a common format for the period of record 1800–1968. In addition, NCC's International Ocean Weather Station data bank was expanded and upgraded. The NCC is currently compiling a digital data file of tropical cyclone tracks for all oceans of the world.

In 1971, under the IDOE program, the NSF awarded a grant to support the Historical Sea-Surface Temperature Program. This WMO cooperative project involves the Federal Republic of Germany, the Netherlands, the United Kingdom, and the United States. Each country will provide historical summaries of sea-surface/air temperatures and wind by year, dating back to 1860. With the aid of computers, nearly 20 million ship-log observations will be published in an effort to produce year-by-year summaries.



Computer technology applications at NOAA's National Oceanographic Data Center have led to such innovations as the "live atlas," a cathode-ray display of various data graphics. Shown here: A display of the four quadrants of the world, a selected quadrant with Marsden Square numbers added (upper right), average annual sea-surface temperatures by 1-degree square for Marsden Square No. 81, and vertical profiles of maximum, minimum, and average water temperature for a selected square and month.

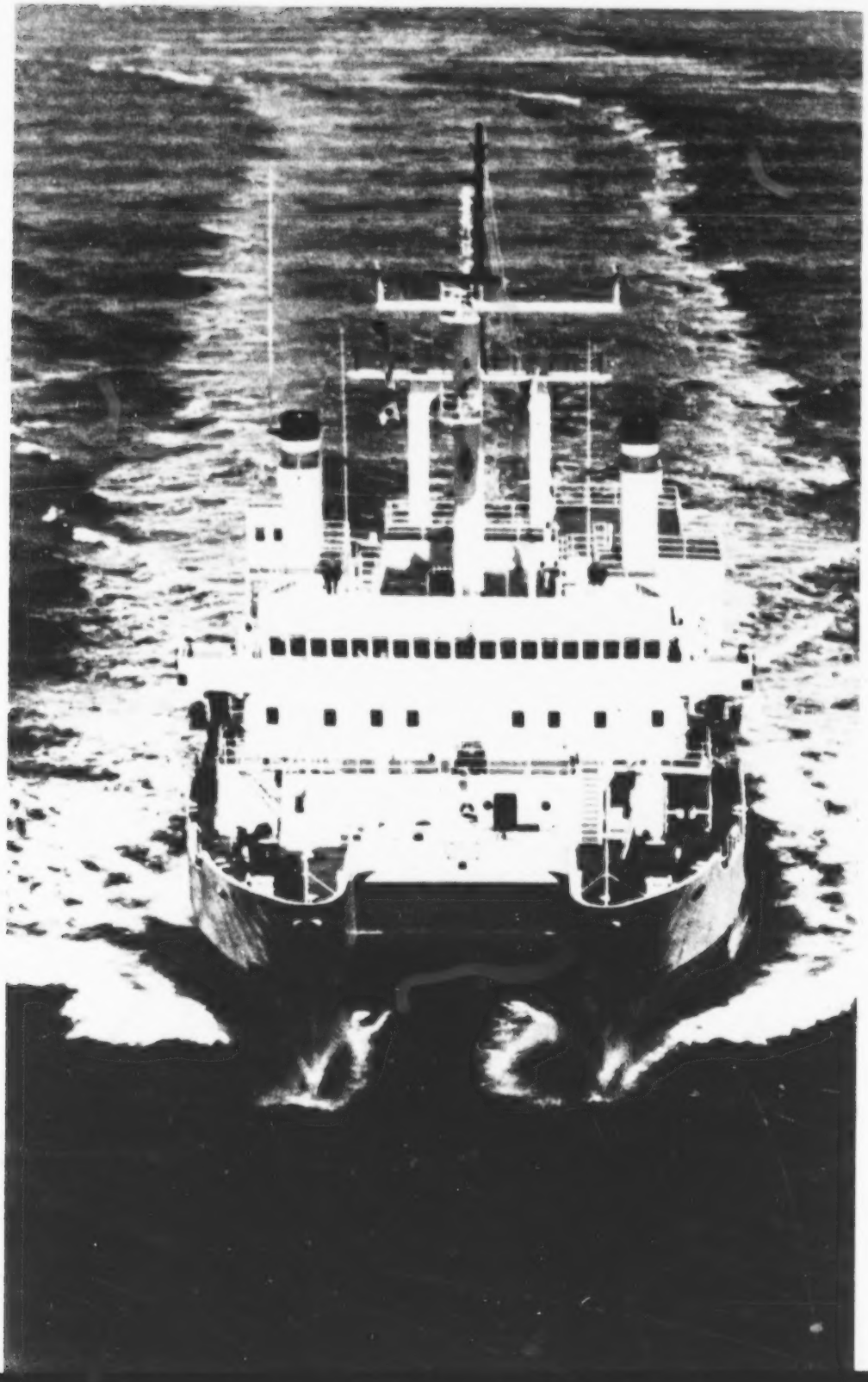
Beginning with a broad data base compiled during 10 years of marine geophysical exploration by the Coast and Geodetic Survey (now NOAA's National Ocean Survey) and from extensive Navy data formerly in the NODC files, the NGDC marine group has rapidly increased its data inventory and, with its IDOE marine geophysical data management responsibilities, will now significantly expand its international data files. In addition, the Naval Oceanographic Office has agreed to provide its unclassified marine geophysical files to the NGDC; in March 1972, the Department of Defense Gravity Library released over 160,000 gravity data points in the U.S. coastal areas to the NGDC.

One of the major programs of the U.S. IDOE effort is that of Seabed Assessment. Approximately 90,000 nautical miles of IDOE trackline surveys were completed in 1971 as part of this program by the USGS and NOAA. Collected data are being forwarded to the NGDC for national and international dissemination.

The Smithsonian Institution Sorting Centers

The two Smithsonian Institution-operated Sorting Centers continued to meet demands for the processing of biological and geological materials collected by national and international marine science resource assessment programs. Together, these centers—the Smithsonian Oceanographic Sorting Center in Washington and the Smithsonian's Mediteranean Marine Sorting Center in Tunisia—sorted and computerized the data for nearly 6 million specimens. Nearly one million specimens were sent to 395 specialists throughout the world.

During 1971, the Tunisian Center also continued to function as the Biological Center for the Cooperative Investigations of the Mediterranean (CIM) and cooperated with the United Nations Educational, Scientific, and Cultural Organization (UNESCO) in training area technicians in the fundamentals of living marine resources.



Chapter V

NATIONAL SECURITY

The portion of the Federal Ocean Program carried out in direct response to the operational requirements of the armed services continues to represent the largest single departmental contribution to the Federal Ocean Program. Much of this contribution reflects the global scale of naval operations and the operations-supporting role of marine science programs in the Department of Defense conducted by the Navy, which also furnishes oceanographic services to the Army and Air Force. Some research and development activity in this area is supported by the Advanced Research Projects Agency (ARPA), usually in response to special naval requirements. The Army Corps of Engineers effort in the marine environment, although run by a military organization, is part of the civil works programs described elsewhere in this report.

There are basic differences in the orientation of military and civil efforts. For example, Navy ocean prediction needs are global and include both physical variables deep in the water mass to support submarine and antisubmarine warfare and air-sea interface phenomena which affect many of its operations on a worldwide basis. The majority of the Navy's products relate directly to the tactical employment of weapons systems. Comparable civil programs, on the other hand, respond to commercial fisheries, the offshore mining industry, the protection of life and property, and so on. Further, geographic areas for operational surveys vital to defense needs may be of low priority in civil sector programs, for civil needs concentrate largely in our coastal and offshore areas.

Defense science and technology, however, are frequently the precursors of major civil capabilities, while the very broad application of the marine sciences to the Navy sustains a Defense Department interest in virtually all civil effort. There is, therefore, constant attention to furthering the rapid exchange of data between military and civil agencies. An important action taken in this regard has been the exchange between NOAA and the Navy of scientific management personnel and the assignment to the NOAA Administrator of a Navy Vice Admiral as Naval Deputy and Associate Administrator for Interagency Relations.

The Navy program is divided into three primary areas: Oceanographic operations, ocean science, and ocean engineering. Funding in these areas

USNS* Hayes (*AGOR–16*), *Navy's newest and world's largest catamaran research ship.* Hayes *gives a new heavy equipment handling capability to scientists studying underwater sound propagation.

is essentially the same for Fiscal Year 1973 as it was for 1972. Changing priorities within the major program areas have required adjustments, however, particularly in the operations area. The changes in Navy's marine sciences program are in consonance with the changes taking place in its operating forces. There are fewer ships in the fleet, new types of ships, and changes in tactical doctrine. As our forces are reduced, it becomes imperative that the remaining units operate at peak efficiency and effectiveness. This can only be done through maximum exploitation of their operating environment. In the most urgent areas, the required knowledge will come from the dedicated programs in the Navy and ARPA; the total need can only be met by a strong national civil program and the efforts of allied navies.

Oceanographic Operations

The operations program ranges from deep ocean and coastal surveys to ocean environmental forecasts and the publication and distribution of nautical charts, publications, and navigational warnings. It is this portion of the program which responds directly to the fleet with operational products and which responds to the statutory requirement to serve all mariners with navigational information.

Our Navy Strategic Forces require extensive information on deep-ocean bathymetric and geophysical conditions. To meet these requirements, the Navy has been utilizing a major portion of its survey fleet. More concentrated effort, however, is required. Although the President's request in the Fiscal Year 1972 budget for conversion funds for an additional major survey ship was denied and severe budget constraints were placed on the entire mapping and charting program, it has been possible to strengthen the program through the replacement of the USNS *Keathley,* a slow World War II conversion assigned to gravity surveys, with the newly constructed 15-knot USNS *Wyman,* originally designed for coastal surveys. In addition, the USNS *Harkness,* one of two new large coastal survey ships which became operational in 1971, has been assigned to gravity surveys for several months en route to her initial assignment in the Mediterranean.

Navy's coastal charting survey program will see a major increase in 1972 as two new large coastal survey ships, *Harkness* and *Chauvenet,* begin combat chart surveys overseas. The new ships, shaken down in a series of surveys responding to civil priorities off the Middle Atlantic Coastal States, have proven to be excellent platforms. Their automated hydrographic acquisition system, helicopter detachment, and modern field-chart reproduction equipment combine into a highly effective survey force.

Surveys will be conducted in the Mediterranean and western Pacific, with continuing operations near South Korea. The USNS *Kellar,* a small coastal survey ship which had been operating in the Pacific, was replaced in the program by the *Chauvenet* and now serves a NATO ally as a joint oceanographic-coastal survey ship. The deactivated *Keathley* has been transferred to a Pacific ally.

A second Navy charting program, based on local resources rather than dedicated survey ships, is the Harbor Survey Assistance Program (HAR-

SAP). This program will continue its dual role of providing up-to-date harbor charts and of training foreign personnel in hydrographic surveying and techniques of chart construction. The HARSAP coordinator, assigned to the Canal Zone, maintains active interchange with the seven participating Central and South American countries, as well as liaison with several additional Latin American countries, and assists in courses given in hydrographic surveying and chart construction at the Inter-American Geodetic Survey (IAGS) school there. Fourteen nautical charts are presently scheduled for production by the host countries as a result of these surveys.

Geodetic surveys in support of operations range from the establishment of shore control for coastal surveys to the positioning of OMEGA and other electronic ocean-navigation system shore stations. A new satellite receiver, the AN/PRR–14 Geoceiver, which operates with the Department of Defense geodetic satellite system, represents a major advance in the capability to tie distant isolated points, such as offshore islands, to a common datum. Navy's international tracking network associated with the geodetic satellite is being augmented by the Geoceivers, and all major Navy survey ships are being outfitted with them.

Navy's oceanographic survey capability has been expanded through the delivery and operational deployment of another ship of the *Silas Bent* class, the USNS *Wilkes* (T–AGS 34). This stabilizes the force level assigned to support the ASW program at three ships, two in the Atlantic and one in the Pacific. In addition to geophysical data, these ships collect acoustic and water mass data and perform special sea-floor studies. Over 700 deep oceanographic stations and almost 100 acoustic stations were accomplished in

Navy's Harbor Survey Assistance Program (HARSAP) brings U.S. technology and engineers together with Central and South American surveyors in a joint effort charting foreign ports and harbors.

1971, and that effort will be exceeded in the 1972 and 1973 surveys of the Caribbean, Northeast Atlantic, and North Pacific.

The Navy's oceanographic survey capability has been increased in other ways as well. The three survey ships are outfitted with the most modern oceanographic and geophysical survey systems, including a computer-centered Oceanographic Data Acquisition System (ODAS). This new ODAS unit was brought to operational status in 1971, and its employment to date indicates this system will greatly improve data-handling capabilities. The second improvement was the successful implementation of acoustic measurements from oceanographic aircraft. Utilization of aircraft and sonobuoys for ambient noise and reverberation measurements allows significant reductions in the time necessary to complete coverage of the extensive oceanic areas with priority requirements.

Oceanographic surveys in coastal and inshore areas to acquire environmental data directly applicable to mine warfare, shallow water ASW, and special warfare planning and operations will continue in cooperation with two European and two Asian countries. These special surveys are carried out under bilateral agreements and utilize host-nation naval ships and military scientists working with Navy scientists. Among the characteristics examined are acoustic propagation, current structure, and sea-floor and subbottom sediments required for effective mining, mine-countermeasures, and other naval operations in shallow water areas. Special surveys in strategic straits are also carried out to provide data required to improve various ASW barrier systems and concepts. These operations provide data concerning the temporal and spatial fluctuation of the ocean currents, sound velocity structure, and the ambient noise field. Two extensive surveys were successfully completed in the Denmark Strait; one in direct support of an ongoing fleet exercise and the second as part of the continuing ASW support program. In both cases, emphasis was on determination of current velocity and physical properties of the Strait's complex structure.

Utilization of Navy's capability to conduct high-resolution surveys of the sea floor is increasing, with operations such as those noted in chapter II and in special surveys of submarine trial areas. The capability of the deep-tow systems is being improved steadily by a dedicated program of system development.

The capabilities for airborne surveys will be greatly increased by the replacement of existing planes by P–3 series aircraft in the near future. The geophysical aircraft, currently a C–54, will be replaced when a new P3–D configured for geomagnetic surveys becomes operational in 1972. The two oceanographic NC–121 aircraft also are tentatively scheduled to be replaced soon by P3–A aircraft as P3–C aircraft are phased into fleet ASW patrol squadrons.

Coastal and deep-ocean survey operations, plus source data obtained through international cooperative agreements, resulted in the production of 162 new or new-edition charts; over 600 corrected reprints of existing charts; 36 new-edition oceanographic atlases, graphics, and publications supporting ASW, mine warfare, and countermeasures; over 12,000 messages concerning maritime safety; 12 new editions of *Fleet Guides* and the first three volumes (on the Mediterranean) of a new 43-volume sailing direction

series which will replace the current 70-volume set. These accomplishments are in addition to the hundreds of products, many of which are classified, which flow directly from the survey ships to fleet components.

Planning for special charts and tables for the worldwide Omega navigation system was completed, and 26 Omega skywave correction tables for seven areas in the North Atlantic and eastern Pacific were published. In addition, numerous charts and tables were published in support of Loran and Loran-C navigation networks covering the Norwegian Sea, North Pacific, U.S. west coast, and Canada. A *Radar Navigation Manual,* H.O. Pub. 1310, was published in response to the mariner's need for a practical and comprehensive radar manual which could be used for rapid referral to various radar techniques and information needed in the performance of ship control and navigational duties. In another new publication effort, the final five volumes of H.O. Pub. 229, *Sight Reduction Tables for Marine Navigation,* covering latitudes 0° to 75°, were completed. The publication series is used for the solution of celestial observations in the determination of ship's position. And finally, the Navy furnished hydrographic data for almost 200 maps and charts issued by the U.S. Army Topographic Command and the U.S. Air Force Aeronautical Chart and Information Center.

By Presidential directive, specific functions of all Department of Defense components' mapping and charting activities are being consolidated into a Defense Mapping Agency (DMA). Details of the DMA organization are still being worked out, but it is planned that all Navy mapping and charting production and distribution activities will be transferred administratively to the new agency about July 1, 1972. Field survey efforts will initially remain assigned to the services, as will data processing functions normally performed by field survey personnel. Although Navy's operational program will be reduced in scope, the level of service is expected to be maintained through the complementary programs of the DMA.

Environmental Prediction

The Navy is responsible for providing oceanographic prediction services for all Department of Defense requirements. To execute this responsibility, the Navy operates a full-service, wide-range ocean prediction system. The core of this system is the Fleet Numerical Weather Central (FNWC) located at Monterey, Calif. Dissemination of products from the main computer processing component of FNWC is provided by the Naval Environmental Data Network (NEDN) through interconnected digital computers and on-line communications equipment. The FNWC processes, disseminates, and displays meteorological and oceanographic analyses and forecasts on a hemispheric basis to meet defense needs. With these facilities, real-time products are continually updated and tailored to fleet and other defense requirements. The FNWC products are distributed through the NEDN to Fleet Weather Centrals and Facilities strategically located throughout the world. Marine prediction products are tailored to the special needs of the users, with much of the specific Navy support classified because of its application; however, a large part of the data collection program and data processing techniques contribute to civil needs. Routine services include wave, swell, and surf forecasts for fleet operations; warnings of significant atmospheric and oceanic

conditions for ships at sea and in port, and for defense shore installations; ice condition forecasts for military operations; prediction for pollution abatement or control, search and rescue, and aircraft ditching; and point-to-point total forecasts such as the Optimum Track Ship Routing program. Most prediction products, however, are concerned with the ocean characteristics which affect the transmission of acoustic energy and are tailored to specific weapon systems.

During 1971, the fleet evaluated the newly developed Automated Shipboard Forecasting System (ASFS) aboard three ASW carrier-group flag ships. The ASFS produces computer-developed displays of environmental data and sonar performance indexes tailored to specific weapon systems for a localized climatic ocean model stored in the computer and modified by real-time observations from Task Group Ships. Major emphasis is being placed on the refinement of prediction methods and the development of local models for the many specific geographic areas of operational interest and on the integration of the system into the multipurpose computer system being designed for the new aircraft carriers.

Publication of 16 more volumes in a series of detailed marine data climatic summaries extended coverage to parts of the coastal areas of the Pacific and Indian Oceans. Computer programs were developed for the automatic introduction of satellite data into sea-surface temperature forecasts, and several operationally new physical models for forecasting underwater sound parameters were introduced. Wave and swell computer analysis was improved through the introduction of significant changes in the operational Northern Hemisphere Wave Program.

Ocean Science

The Navy Ocean Science Program consists of a broad spectrum of physical, chemical, biological, and geological oceanographic studies in support of military requirements. It ranges from the contract research program of the Office of Naval Research, which by its basic nature holds major civil benefits, to the investigation of the propagation of acoustic energy in the ocean medium. Much of this effort applies almost exclusively to national security needs and is classified. Even here, however, supporting nonacoustic environmental data collected are normally unclassified and are made available to the general ocean community.

Within the ocean, sound remains the only practical means of transmitting or receiving information beyond a few hundred feet. Transmission-loss research and development is concerned with the identification and evaluation of the many paths by which sound can travel from a source to a receiver in the sea. A combined theoretical and experimental program is underway to further understanding of these paths through experiments at sea and computer simulations.

Several numerical models are required because Navy sonar systems encompass a broad spectrum of frequencies and ranges. One of the most difficult aspects of nature to simulate with a computer, and one of the most important to both active and passive systems, is the interaction of the traveling sound wave and the bottom. Extensive measurements have been made by

means of an evolving series of geological or geophysical instruments of increasing precision and discrimination. These methods are providing increasingly accurate data on bottom topography and roughness which aid in understanding reflection loss at the bottom as a function of composition, roughness, frequency, and grazing angle.

Ambient noise is also a primary concern. Because sonar systems must detect their target signal against a background of noise, it is necessary that the noise field be as well understood as transmission and scattering phenomena. Present investigations are concerned with identifying the possible sources of the noise, measuring their source strength, and statistically describing their fluctuation in time. In addition, measurements of ambient noise as a function of depth and of both horizontal and vertical directionality are important aspects of the program. Interim models for the prediction of ambient noise are being developed, validated, and improved as new understanding of the physical processes is developed.

Major experiments were conducted during the year in the Mediterranean Sea and in the North Atlantic, North Pacific, and Indian Oceans to measure biological reverberation, bottom loss, scattering layers, ambient noise, and other characteristics. An acoustic transmission study—the first of its kind—between Cobb Seamount and another undersea mountain off the Pacific coast gave particular attention to the effect on propagation of the water mass microstructure. Six east and gulf coast studies were made using the stable buoy platform SPAR (Seagoing Platform for Acoustic Research) and an AGOR (Auxiliary General-Oceanographic Research) ship to support development of models to predict the environmental effects on weapon system performance.

During 1971, an instrument to record noise level at several successive depths beneath a ship was developed. It free-falls to preset depths, hovering for a period of time at each before sinking to the next. At the end of the cycle, the instrument becomes buoyant and returns to the surface for recovery by the launching ship.

USNS *Hayes* (AGOR–16), the world's largest catamaran research ship, was accepted last year. The 3,100-ton *Hayes* will give Navy a major new capability to handle heavy research equipment over the side when outfitting and shakedown are completed in 1972. *Hayes* replaced the USNS *Gibbs,* a World War II conversion which will see continued service as a hydrographic and oceanographic survey ship in the navy of a European ally.

The Navy's contract research program, carried out primarily through academic institutions, continues to achieve goals which hold potential for enhanced naval operations. Among these are developments applicable to the coastal zone such as remote-sensing reconnaissance methods; two- and three-dimensional mathematical simulation of river mouth processes; computer models of beach water-table fluctuations, wave characteristics based on hindcasting and coastal conditions, and the effect on effluents of sea water and freshwater density differences; and new concepts of shallow water wind-driven currents, the action of a meandering current in the surf zone, and the relation between longshore currents and barometric pressure.

Research on the Arctic generated new knowledge of the relation of river ice breakup to fresh-water flooding under the ice; the exchange of water

masses into and out of the Arctic Ocean; the freezing of sea ice and the processes which alter its properties; the geothermal and crustal properties of the sea floor; the carbon monoxide budget of ice-free and ice-covered areas; sound-scattering layers and underwater acoustic propagation in the Polar Basin; and as the results of joint aircraft and submarine projects, the relation between under ice and surface sea-ice roughness.

Important advancements occurred in instrumentation and techniques, such as an improved capability to measure radioisotopes in ocean water; a simple capacitance water-level detector system to measure both swash and beach ground water and an integrated sensing system for monitoring the important coastal zone process variables; a new means of determining the presence and distribution of minerals in unconsolidated sediment cores by thermoluminescence; a technique for semiautomatic plotting of shallow bottom topography from remote-sensor data; a small, portable field gas chromatograph for rapid determination of the composition of dissolved gases in coastal waters and a deep-ocean device for measuring the *in situ* partial pressures of dissolved gases such as carbon dioxide and methane; a digital-readout pivoted-vane current meter for simultaneous measurement of vertical and horizontal velocity components; an acoustic velocimeter for measuring the acoustic properties of sea-floor sediments *in situ;* and numerous special systems for water-mass acoustic research.

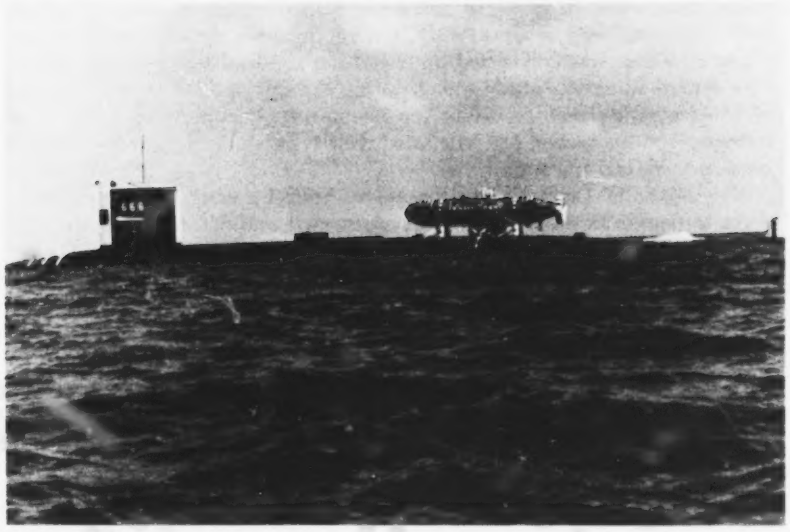
Enhancement of ocean prediction and theory was achieved by the collection of substantive evidence and definition of drag coefficient dependency on atmospheric stability over the open ocean, extensive modeling of weather over the ocean to treat special problems, significant advances in the reliability of buoys and the special internally recording data systems planted and recovered in deep waters of the rough North Atlantic, development of reasonably accurate models demonstrating the modification of wind velocity from offshore to onshore, and findings on the salt concentration in coastal aerosols as a function of wind velocity.

Water-quality program enhancement came through major estuarine and coastal dynamics studies and modeling, determination of the changes in ocean background levels of major isotopes from nuclear power reactors ashore or past nuclear weapons tests, and determination of chemical pollutant effects at various concentration levels on marine algae.

Ocean Engineering

The ocean engineering program has as its objective the development of technology to enable the Navy to operate anywhere, and at any time, throughout the depths of the ocean. It is also a major source of developments related to national civil needs. Among its key projects is the Deep Submergence Rescue Vehicle (DSRV), developed as an all-weather submarine rescue system and operable to beyond submarine hull collapse depths.

DSRV–1 was accepted by the Navy in 1971. In tests, DSRV–1 mated with the simulated distressed submarine facility installed at a 170-foot depth off San Clemente Island, Calif., and completed a successful underway mate with the "mother" submarine USS *Hawkbill* (SSN–666) at a 270-foot depth. The *Hawkbill* mate included the transfer of personnel between the two



The USS Hawkbill *(SSN–666) with Deep Submergence Rescue Vehicle–1 on the surface after a successful underway hookup at a depth of 270 feet.*

submersibles. Submarine Development Group (SUBDEVGRU) One, which operates Navy submersibles *Trieste II, Sea Cliff,* and *Turtle,* and extensive saturated diving systems, is conducting an 18-month operational evaluation of the vehicle.

Originally built to operate at a maximum depth of 3,500 feet, DSRV–1 is being readied for certification to 5,000 feet as the result of model tests and further research on spherical hull design which show that the deep-depth limit can be achieved with no increase in structural weight. DSRV–2, already certified for a 5,000-foot depth capability, commenced builder trials at sea in 1971. It should be accepted by the Navy in April 1972 and complete its operational evaluation late in 1973. SUBDEVGRU One will ultimately operate both DSRVs from a Rescue Unit Home Port authorized for construction at North Island, San Diego.

Navy has concentrated much of its expertise in underwater construction in an operational unit under the Facilities and Engineering Command (NAVFAC) of the Naval Material Command. This new unit, as part of the Chesapeake Division of NAVFAC, has undertaken a number of tasks including, in 1971, the recovery, repair, emplantment, and cabling to shore of much of the new NATO Azores Fixed Acoustic Range (AFAR) equipment. Effort on AFAR also included extensive utilization of the deep-recovery vehicle CURV III. The 24 separate dives made by CURV III in a 42-day period amply demonstrated the reliability and maintainability of that system.

During 1971, emphasis was placed on development of various advanced components for a 20,000-foot remote unmanned work system and on sea-floor construction tasks. For example, underwater "dry-make" and "wet-

make" connectors, designed to operate at 6,000-foot depths, were developed and fabricated and are currently undergoing long-term immersion tests.

Construction was completed on a 100-ton rigid salvage pontoon system. The system was successfully tested during the fall of 1971 in water depths of 150 feet using compressed air for dewatering. Further tests, using liquid nitrogen and hydrazine, are scheduled. Initial indications show the variable buoyancy control is working well.

The Mark II Deep Diving System successfully completed certification dives to depths as great as 935 feet unmanned and 850 feet manned. The operational evaluation will be completed by the end of Fiscal Year 1972 when divers who are saturated to a depth of 850 feet will use the system to make excursion dives to 1,000 feet.

In biomedicine, Navy developed and is field-evaluating portable bubble-detection devices as an aid to detecting decompression sickness; implemented, with America's allies, an international decompression data bank; conducted initial animal studies with drugs protective against decompression sickness and oxygen toxicity which show a markedly beneficial effect and suggest future human use; and completed studies demonstrating the feasibility and safety of neon as a diver breathing gas.

In support of submersibles, a 20-kilowatt gaseous hydrogen-oxygen fuel-cell breadboard power module was developed for a protected one-atmosphere operation in a deep submergence vehicle. It will undergo testing and evaluation this year. Significant progress was achieved in the area of advanced imaging systems. Low-light sensitive television (TV), polarization-discrimination, volume-scanning, and range-gated systems were developed and evaluated.

Another recent achievement in improved materials for ocean applications was the development of a syntactic foam for use at 20,000-foot depths. This will result in a 30-percent reduction in total vehicle weight of future deep submergence systems.

Various prototype underwater systems and components were developed and demonstrated in the ocean environment to assess the feasibility and potential technical performance capability of advanced systems. The more significant of these are: the Transparent Hull Submersible (THS) *Makakai,* a two-man free-swimming submersible with an operating depth of 600 feet, affording the two operators an unobstructed panoramic view of the outside surroundings; an 18- by 35-foot towed-catamaran-designed Launch and Recovery Platform (LARP), providing a stabilized platform for underwater launch and recovery of submersibles; a recovery device, AIR CLAW, designed to work with a submersible and able to recover items ranging in diameter from 12 to 18 inches and weighing up to 400 pounds; a lift-cable transfer unit designed to carry a heavy lift cable down a light messenger line to a point of attachment, to which the messenger cable was previously secured, on an object resting on the sea floor; a Diver's Navigation System (DNS) designed to operate to depths of 850 feet for assisting divers or submersible operators in orienting themselves in the ocean environment; SNOOPY, a surface-control, TV-equipped undersea vehicle which can replace a diver for many tasks to depths of 100 feet; and a Buoyancy Actuated Launch and Retrieval Elevator (BALARE) designed to provide a submer-

sible with a stable platform for launch and recovery free of the air-water interface and wave action, yet positively controlled by the surface support vessel.

As a byproduct of this deep ocean effort, handbooks have been issued on lubricants and compensating fluids, electric cable technology, vehicle electrical drive systems, electrical insulation, rotary seal selection, electrical and electronic circuit-interrupting and protective devices, and design and selection of advanced underwater optical-imaging systems.

ARPA Marine Science and Technology

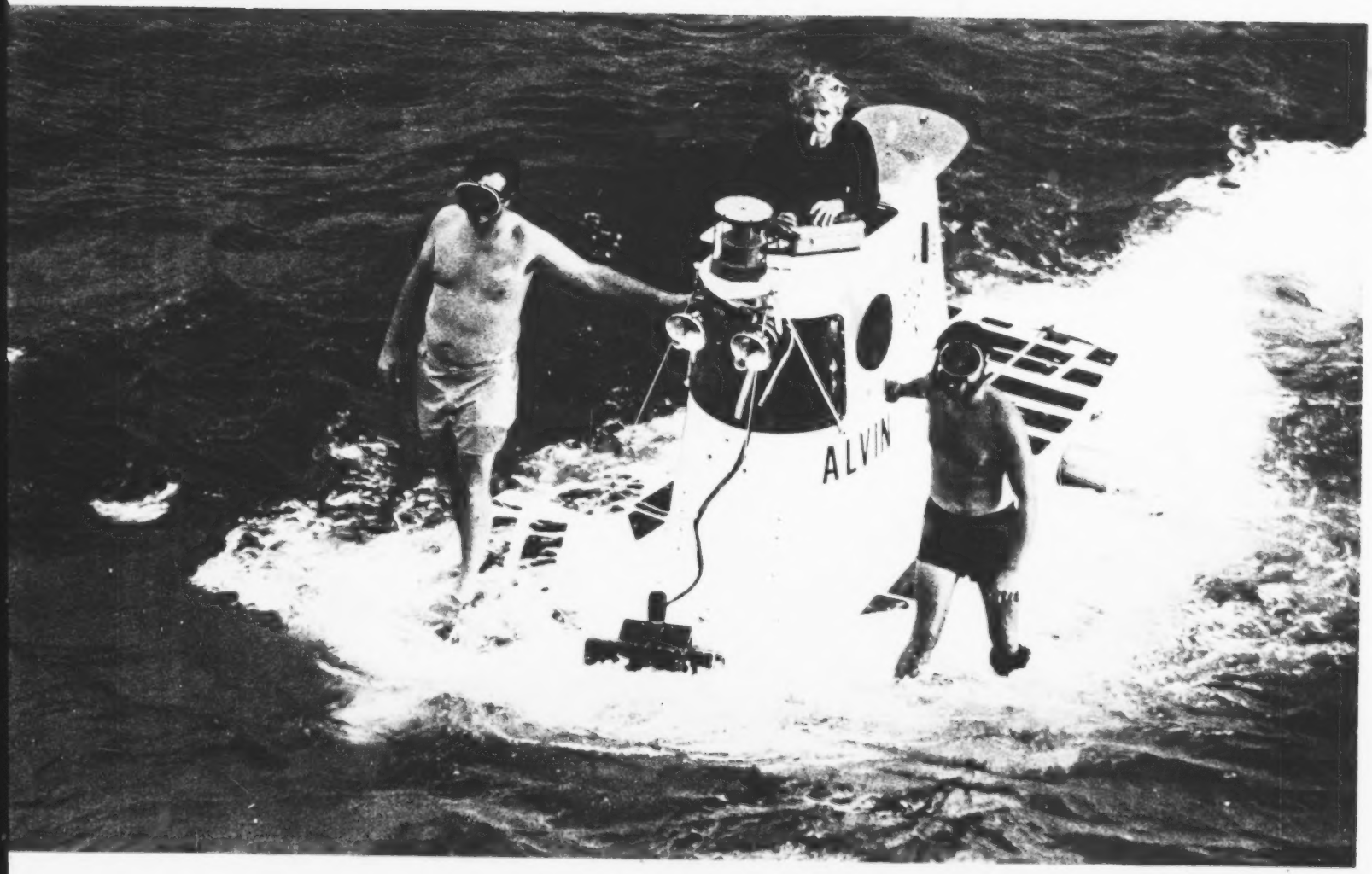
The ARPA sponsored four major programs in marine science and technology during 1971.

Development of stable floating platforms was continued with emphasis on lower cost and greater mobility for a wide variety of military missions, ranging from research to operations. The construction of a 15,000-square-foot, 500-ton-payload platform of the column stabilized type (four legs and two modules) is planned for application to research on large sonar arrays. Research related to the use of inflatable members and decking for platforms has been initiated.

As a part of the Arctic Operational Technology Program, design specifications were completed for an unmanned arctic research submersible and its support system for launch, control, tracking, and recovery. This is a fiberglas hull, blunt-nosed, torpedo-shaped device about 9 feet long and 2 feet in diameter capable of excursions to 1,500-foot depths and sustaining a speed of 3 knots for a 10-hour period. It will follow a preprogramed track, but may be remotely controlled by means of acoustic telemetry links. Primary use will be for collection of under-ice profiles in the Arctic Basin and marginal sea-ice zone, together with temperature and salinity data along its track. Field tests will be conducted in the Arctic during 1972 in conjunction with the Arctic Ice Dynamics Joint Experiment (AIDJEX).

Another arctic effort is to develop and demonstrate the technology required to exploit the arctic military potential of the Surface Effect Vehicle (SEV). The SEV is the only known surface vehicle with the potential to traverse the variety of arctic surfaces (ice, open water, mixed ice and water, snow, frozen tundra, and swamplike thawed tundra) which exist during all or part of the year. Two major segments of the program presently underway are arctic environment definition and vehicle and subsystem technology development.

Finally, ARPA's Ocean Monitoring Program is directed toward developing the capability for monitoring natural and manmade phenomena on the surface and within the sea and seabed. Included are electromagnetic techniques for surface phenomena, acoustic and optical technology for undersea sampling, and use of submersibles.


ALVIN

Chapter VI

ADVANCING THE NATIONAL CAPABILITY IN MARINE SCIENCES AND TECHNOLOGY

Behind the emphasis in the Federal Ocean Program on marine life and environment and on resource management and improved levels of marine scientific services, a broad program of supporting research and development is building the capabilities we must have today and tomorrow. Such efforts conducted by the Federal agencies, or supported by them in commercial and private institutions, work at the threshholds of marine science and technology. From them will come new generations of scientific talent and marine science services, knowledge and hardware man needs to live and work beneath the sea, new views of our planet's history, ways to measure oceanic processes from space, and continued impetus for American success in marine transportation and commerce.

Major programs of cooperative research take massive arrays of instruments and platforms into the marine environment and provide opportunities for early applications of new knowledge and technology. This effort links Federal agencies in projects in the interest of States and the Nation and links the United States with other nations for the benefit of all mankind.

Sea Grant

The year 1971 marked the beginning of what may be described as "phase two" of the Sea Grant institutional program. The relatively small universities were able to organize quickly for broadly based Sea Grant institutional operations, but the larger universities, faced with problems of structuring that the multidisciplinary program Sea Grant requires, began more slowly. In September 1971, one of the original intents of the Sea Grant College and Program Act was achieved when the Secretary of Commerce designated the first four Sea Grant Colleges—the University of Washington, the University of Rhode Island, Oregon State University, and Texas A&M University.

Sea Grant programs were developed on all nine campuses of the University of California system under the leadership of the La Jolla campus and

The research submersible, Alvin, *returns from a successful dive in the Florida Straits. Capable of diving to 6,000 feet,* Alvin *is representative of the new-generation vehicles behind Manned Undersea and Technology activities in the Federal Ocean Program.*

Scripps Institution of Oceanography. Massachusetts Institute of Technology, which had produced a valuable series of ocean engineering course books under Sea Grant projects, developed a full-scale program during 1971, and rapid expansion of Sea Grant programs took place at the Universities of Hawaii, Michigan, Washington, and Wisconsin. Two universities, Delaware and Louisiana State, which began Sea Grant activities as multidisciplinary coherent projects, reached a stage of development justifying their proposals for full institutional status in 1972. By mid-1971, institutions in 27 States, the District of Columbia, and the Virgin Islands were participating in the Sea Grant program through project grants.

Sea Grant goals in 1971 continued to involve scientists and engineers in the practical problems of the marine environment and to accelerate the flow and application of results from research started in previous years. In 1971, there was a particularly hard look at educational programs, evaluating those under Sea Grant funding in terms of probable trends in the manpower market.

In spite of cutbacks in marine and marine-related industries, Sea Grant technician-training programs continued to maintain their high record of graduate placement with 100-percent employment reported in several instances. The lowest placement record was 85 percent for the marine industry; but even here, the remaining 15 percent found jobs in which their newly acquired skills were useful. Sea Grant began gradually to modify its training programs, responding to the demand for fisheries technician training and for a limited number of activities in marine engine and diesel mechanics, while reducing the number of oceanographic aide projects.

In all, 89 Sea Grants were underway in 1971. These grants encompassed 361 separate research projects, 11 education and training projects, and 96 advisory service activities, with 2,656 persons participating.

Development by Oregon State University of a hydraulic system powered by a fishing vessel's outboard motor has made it possible for the dory fisherman to increase his income substantially. This significant 1971 development is now being exported to the U.S. Trust Territory of the Pacific Islands. Arrangements have been made to provide technical assistance through Oregon State University for boatbuilding facilities constructed in American Samoa under Office of Economic Opportunity funding.

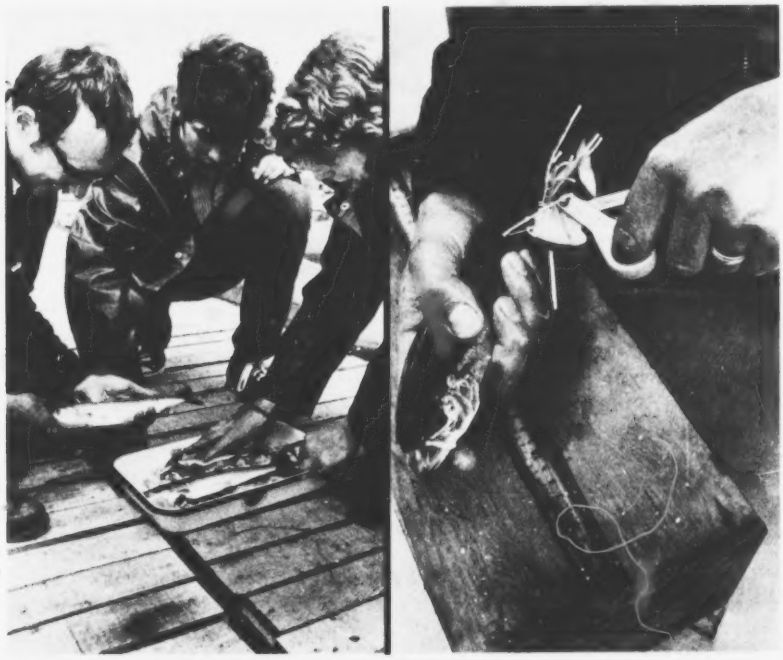
Successful out-of-season spawning of mullet was achieved by a Sea Grant project at Hawaii's Oceanic Institute. Instead of waiting for the mullet to spawn naturally, as in the past, it is now possible to bring about spawning on demand and over shorter intervals—a requirement for success in any farmed species. This capability opens the door to selective breeding experiments which, in turn, can lead to greater productivity and a more desirable product in terms of size, taste, and disease resistance. Of great importance is the potential transferability of the technique to higher value species.

Culmination of mariculture experiments by excellent harvests in Angleton and Orange County, Tex., brought commercial shrimp farming a step closer to reality during 1971. These experiments at Texas A&M University make use of the high productivity of marshlands with minimal disturbance to their natural state. Ponds were created to serve as habitats for the shrimp, which received some supplemental food but were essentially left to live off the natu-

ral plants and animals that exist in the marshlands. Thus, the technology of raising shrimp has been taken out of the laboratory and transferred successfully to the field; it is now possible to conduct the experiments under larger scale, more natural conditions. In addition, the experiments brought into the program those individuals from the industry with potential interest in exploiting this technology.

Last year saw the establishment of the Pacific Sea Grant Advisory Program, which encompasses California, Oregon, Washington, Alaska, Hawaii, and British Columbia. Up to this point, various marine advisory programs existed in State universities, servicing principally the State in which the university was located. The creation of the regional program is the first time that local advisory groups have been able to join forces to solve regional problems such as, for example, those of the Northwestern Pacific fisheries.

This year Sea Grant brought lawyers into active consultation with their communities. Legal studies in Sea Grant institutions have provided a base for development of legislation, alerted State and local officials to problems posed by existing legal regimes, provided advice to conservation groups, translated legal technicalities into a form useful to fishermen and others, and contributed substantially to the development of background on international law of the sea. Sea Grant economists have conducted studies ranging from the



University of Washington graduate students and a student from France discuss the production of pen-raised trout and salmon of marketable size. Trout tagging (shown at right) identifies individual fish in this experiment.

value of extending the Great Lakes shipping season to specific guidance on bookkeeping for fishermen and small seafood processors.

Dissemination of research results to users has long been a key objective of the Federal Ocean Program, particularly where it concerns fishermen whose work takes them out of reach of the usual routine forms of communication. Accordingly, much of the year's activity centered in extending advisory services, a broad category of activity that includes all useful forms of communication to user audiences. This effort to provide the Sea Grant equivalents of county agents in hip boots is working well. For example, one agent helped smoked-fish processors upgrade their operations to meet new FDA standards and also helped industry devise new ways of convenience-packaging seafood family meals.

In the coming year, while Sea Grant efforts in marine environmental research, in development of marine technology and resources, and in education and training continue with modest growth, major emphasis will go to advisory services, primarily in the form of industrial workshops, advisory bulletins, and training of marine-oriented extension agents.

A broader NOAA Marine Advisory Service, also aimed at putting marine resource information into the hands of those who need it most, will begin in 1972, carried out by NOAA with its focus in the Office of Sea Grant. This National Service will use the framework of the Sea Grant advisory extension activities to insure solid contacts at the State and local levels and the special abilities of NOAA's major elements—Environmental Data Service, Environmental Research Laboratories, National Environmental Satellite Service, National Marine Fisheries Service, National Ocean Survey, and National Weather Service. Several of these (for example, the National Marine Fisheries Service) have well-established marine advisory programs that will be coordinated and supplemented through the National Marine Extension Service program.

The way the program operates in the field is suggested by this recent example. Oregon fishermen required a new kind of chart, and, working through local Sea Grant advisory service personnel who helped them specify what they needed, contacted the National Ocean Survey. The Survey then provided the base chart, bottom-sediment data, and technical cartographic and production assistance while the Sea Grant program provided additional sediment data, produced the rough chart, and specified user requirements. When the charts were published, the local program helped distribute them to the fishermen. It is expected that the National Marine Extension Service will be for those who use the sea what the Agricultural Extension Service has been to those who farm the land.

Manned Undersea Science and Technology Program

The establishment and organization of NOAA's Manned Undersea Science and Technology (MUS&T) office in mid-1971 strengthened the national base for the systematic pursuit of a nonmilitary manned undersea program. The MUS&T office, which supports and coordinates the program, maintains close liaison with the Navy to insure beneficial transfer of technology and hardware from military to civil applications.

MUS&T programs are closely linked to implementing coastal zone conservation and management, surveying and assessing the living and nonliving resources of the Continental Shelf, and developing a thorough understanding of dynamic ocean processes. Present and future manned undersea projects aim at extending man's ability to operate in the underwater environment through technological innovation—ancillary manipulators, improved diver life-support systems, search and recovery gear, scientific equipment, submersibles, and underwater laboratories.

During the last half of 1971, a representative and promising series of basic and applied science projects were begun utilizing the existing submersibles and habitats. These are expected to act as "seeding" endeavors which will give initial direction to much more extensive regional programs in the future. By the end of the first year of operation, the MUS&T program will have utilized over 100 scientists, six submersibles, and two underwater habitats to carry out key scientific programs.

The New York Bight study investigated near-bottom sediment dispersal processes, using a small survey submersible. The objective was to increase understanding of solid waste and residual aggregates in support of more effective waste-disposal planning. Off the New England coast, the first phase of a submersible-centered study of herring, lobster, and other resource recruitment discovered lobster colonies in unexpected locations and shrimp beds with commercial potential.

The New York Bight pollution and waste dispersal studies will be extended to the 5,000- to 6,000-foot level into deep submarine canyons. On the west coast and in the Gulf of Mexico, submersibles will be used in similar studies to assess the long-term effects of toxic dumping sites on the marine environment and the effect of pollution on living resources. Additional living resource studies will be conducted in the coming year in the Gulf of Maine to follow up the initial lobster and herring findings. This program will employ for the first time a diver lockout submersible which permits scientists to enter the water while the vehicle is submerged.

An investigation of the Pacific walrus from a small research submersible was conducted in the Bering Sea early in 1972 as a demonstration project of the Marine Mammals Program for the U.S. International Biological Program. It was supported jointly by the Navy, NSF, and NOAA.

A Bahama Banks project, started in 1971, combined a small habitat and submersibles in investigations of marine biology and important geological features. This project revealed a deeply submerged terrace near Nassau, Bahamas, that correlated well with the worldwide distribution of lowered sea floor. Other studies in the Bahama Banks provided new data on the effectiveness of fishtraps and the behavior of selected species. These latter studies are being correlated with similar efforts in the Caribbean and along coastal regions of the U.S. Northwest and Florida. A geological study in the Straits of Florida in November 1971 used small survey submersibles to measure mass physical properties of sediment dispersal, currents, and "karst" topographical features.

The FLARE (Florida Aquanaut Research Expedition) seeks to improve our basic understanding of reef ecology and human impact in the Straits of Florida. Submersibles and a small portable survey habitat were used in

Last year's investigation on the Bahama Banks combined research underwater habitats and submersibles to investigate marine life and geology. Here, the scientist-diver photographs living coral as divers in background prepare to enter the Perry Hydro-Lab.

FLARE, which began early in 1972. The FLARE should provide information on the ecological effects of ocean dumping and other problems of coastal zone management.

NSF Oceanographic Facilities and Support

The NSF Office for Oceanographic Facilities and Support (OFS) was established in 1971 to improve management support for academic oceanographic facilities. The objective is to provide support for large and expensive facilities which are appropriate for shared usage in accordance with the demonstrated needs of the total academic oceanographic community. Institutions qualifying to operate shared facilities will be required to demonstrate the logistic capability to carry out all related tasks.

Support is provided through partial or total funding of ship operating costs and the operating cost of facilities other than ships. Included on a shared basis with Navy are the administrative costs of the University-National Oceanographic Laboratory System (UNOLS).

The UNOLS will provide a considerably improved communitywide coordination and review of the utilization and opportunity for access to facilities. It will assess the current match of facilities to the needs of academic oceanographic programs and recommend priorities for replacement, modification, improvement, and augmentation of facilities. Further, it will assist Federal agencies in achieving more effective ship and other facility utilization.

At present, the academic fleet operated by 18 academic oceanographic institutions includes 32 ships; 11 are Navy ships bailed to institutions, 20 are directly owned, and one is chartered. The estimated fleet operating cost for Fiscal Year 1972 is $16.8 million, shared by NSF (63 percent), Navy (29 percent), and other primarily non-Federal sponsors (8 percent).

The OFS is currently placing emphasis on the replacement of 13 ships ranging in age from 23 to 49 years, on upgrading the capability of ships planned for continued service, and onshore construction and equipment acquisitions necessary to sustain ongoing ship operations.

Ocean Sediment Coring Program

The objective of the Ocean Sediment Coring Program is to acquire knowledge of the nearly three-quarters of the earth's crust that is covered by the sea. The major activity, the Deep Sea Drilling Project (DSDP), commenced in 1966 under an NSF contract with the University of California. Actual operations began in 1968 with the completion of the drilling ship *Glomar Challenger,* the only ship in the world with the capability to perform rotary drilling in the very deep oceans (to 20,000-foot ocean depths). During 4 years of operations, cores have been taken from the Atlantic, Pacific, and Indian Oceans, the Gulf of Mexico, and the Caribbean, Mediterranean, Bering, and Red Seas. Cores have been obtained from the ocean bed in water up to 20,000 feet deep, with some samples taken from holes drilled more than 4,000 feet into the ocean floor.

The scientific results of the Project have contributed to significantly new

understanding of the physical processes occurring in the earth's crust. For example, core analyses have helped to confirm the new theory of sea-floor spreading, which explains the horizontal movement of continents away from midocean spreading centers, and have indicated that some of the marine basins, such as the Gulf of Mexico and the Mediterranean Sea, have the potential of producing oil from rock located below water thousands of feet in depth.

Noteworthy in the conduct of this Project has been the international participation. Foreign contributions have included shore laboratory analyses of cores, site surveys by oceanographic ships, and some logistic support; 56 foreign scientists have participated in scientific cruises aboard *Glomar Challenger* through January 1972.

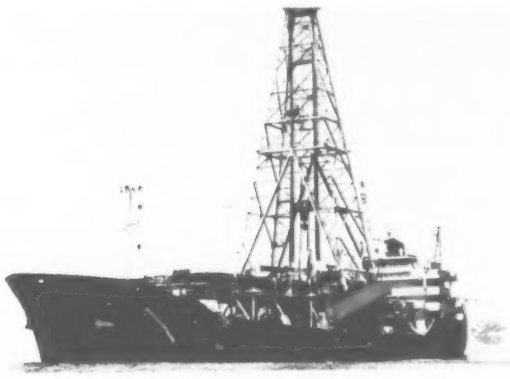
Drilling and coring operations are conducted aboard the *Glomar Challenger,* owned by Global Marine, Inc., under contract to Scripps Institution of Oceanography. Scientific guidance to Scripps is provided through the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES), a consortium of five academic groups.

Oceanography From Space

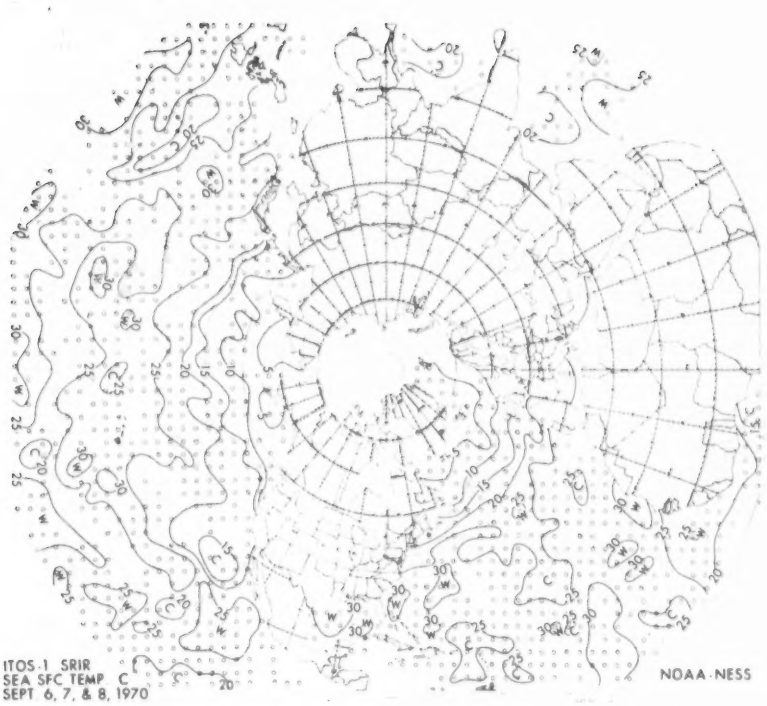
The success of earth-orbiting meteorological satellites has led to a growing effort to apply space technology and remote-sensing techniques to monitoring the marine environment. Many Federal agencies—NASA, the Departments of Commerce and the Interior, Navy, the Corps of Engineers, and EPA—are working closely to identify and conduct research and development toward the operational use of airborne and satellite-borne remote-sensing techniques to monitor oceanic environmental conditions in coastal regions and in the open ocean. As noted in chapter IV, some "wet" products—for example, sea-surface temperature maps from NOAA satellites—have begun to enter operational service.

During March 1971, a NASA aircraft obtained passive microwave and infrared data as it overflew the arctic icepack off the north coast of Alaska. Flights were timed to coincide with the presence of on-the-ice scientists conducting research related to AIDJEX, who could provide "ground truth" information required for the interpretation of the remote-sensor data. Passive microwave techniques were found to be a powerful all-weather tool for investigating the distribution of old and new sea ice and water ponds on the ice, and for detecting the ice-water boundaries. Also in 1971, color photography from aircraft and spacecraft was used to locate upwelling regions and color fronts; to trace sediments, river effluents, and pollution; to study coastal circulation and biological coloration; to identify water masses; and to chart underwater features in coastal areas. Spectroradiometer data from airborne instruments were successfully used to identify sewage, chlorophyll concentration, red tides, and certain pollutants. Automated processing techniques have been developed for objective color mapping, using spectrometer data.

The Manned Spacecraft Center at Houston, Tex., is providing infrared-sensing data from aircraft for use in an interagency assessment of the thermal effects of water discharged from a Trinity Bay powerplant. At the Mississippi



A unique ship, the deep-drilling **Glomar Challenger** *continues to provide the sedimentary evidence behind much of present-day plate tectonic theory. Supported by the National Science Foundation, the ocean sediments drilling program will extend its exploration into the deep ocean off Antarctica, following the tracks shown.*



Data from polar orbiting NOAA satellites have been transformed into several oceanographically useful products. Here, infrared scannings have been translated into a map of sea-surface temperature, a fundamental step toward longer range, reliable environmental prediction.

Test Facility, NASA, in conjunction with the USGS and NOAA, is investigating multispectral scanner techniques as a tool for studying and monitoring water salinity, turbidity, chlorophyll content, forms of pollution, and fisheries activities.

NASA's Langley Research Center and Wallops Station in Virginia are cooperating with many Federal agencies and private groups who are actively investigating the Chesapeake Bay region by obtaining and analyzing microwave data and thermal infrared observations from aircraft overflights. NASA is working with the Virginia Institute of Marine Science in evaluating remote-sensing techniques for detecting and assessing coastal erosion processes, for determining thermal circulation in the James River before the startup of a nuclear powerplant, and for assessing the behavior of controlled oil spills.

Infrared data are being acquired in the Delaware River area for the Corps of Engineers for use in assessing heat-dispersion studies for the Delaware River model located at the Corps facility at Vicksburg.

At its Lewis Research Center at Cleveland, NASA has initiated a program to use infrared and microwave remote-sensing techniques to monitor the

characteristics of ice in the Great Lakes in cooperation with the Corps of Engineers and NOAA.

NOAA has conducted tide and tidal current surveys using remote sensors from NOAA and NASA aircraft, and has also investigated coastal-boundary mapping and wetlands identification and mapping by means of infrared and visual photography.

Many of the cooperative regional coastal zone investigations will be augmented with the launching of the Earth Resources Technology Satellite (ERTS–A) in June 1972. The ERTS–A will carry a three-color television camera system and a four-band multispectral-scanning spectrophotometer. Data from these sensors will be analyzed to determine their utility in coastal zone investigations as well as in open-ocean color and sea-state investigations.

In addition to the unmanned ERTS mission, NASA is planning a manned earth-orbiting mission, *Skylab,* during 1973. *Skylab* will carry an Earth Resources Experiment Package (EREP) consisting of a four-color camera system, a 14-channel multispectral scanner covering the visible and the thermal infrared bands of the spectrum, an active microwave system for sea-state measurements, and a passive microwave system for ocean-temperature measurements.

The Earth Resources Survey (ERS) program of NASA currently transfers funds to NOAA and Navy to develop and utilize techniques for remote sensor data from aircraft and existing satellites. Sea-state information is being derived from the analysis of sun glint in time-lapse photography from the Applications Technology Satellite (ATS) spacecraft in synchronous orbit about the earth. In the Improved Tiros Operational Satellite (ITOS) spacecraft, use is being made of infrared sensor data to produce maps of the horizontal sea-surface temperature gradients for studies of current dynamics and the movement of water masses. Infrared imagery is being used to map the physical condition of ice in the polar regions. The data-handling and interpretation techniques developed by NOAA will be applied to the remote sensor data to be provided by ERTS–A and *Skylab*. NOAA will operate an ERS Data Center to service the needs of the oceanographic community for ERTS–A and *Skylab* data. Many Federal agencies will participate in the evaluation and application of these data to their marine programs. In 1972, the NASA-supported effort will be concentrated in NOAA, with Navy transferring responsibility for its Spacecraft Oceanography Project (SPOC) to the National Environmental Satellite Service of NOAA.

Automated processing and enhancement of multispectral scanner data and multiband photographic imagery were used to locate ocean-color fronts, upwellings, water masses, and biological pigments for fisheries applications. In another fisheries-related development, low-light-level television-image-intensification techniques for locating luminescent organisms agitated by fish schools were demonstrated.

In addition to the application of remote-sensing techniques from space to observations of oceanic environmental conditions, investigations are being conducted on the application of space technology and related precision-satellite-ranging techniques to the extension of geodetic control points to the floor of the open ocean and to the direct determination of mean sea-level and the departures of the ocean-surface geometry from mean sea-level.

In 1974, NASA plans to launch the Geodetic Earth-Orbiting Satellite (GEOS–C), a geodetic spacecraft equipped with a radar altimeter designed to measure ocean-surface slopes associated with open ocean tides, ocean currents, and gravitational anomalies. This GEOS–C mission will provide the opportunity to conduct a feasibility experiment with the Apollo tracking ship *Vanguard* for the establishment of a geodetic control marker on the ocean floor with a horizontal accuracy of 10 meters relative to a geodetic control marker on land. NOAA and the Department of Defense are cooperating in this experiment.

Transportation

Maritime transportation of all types is essential to the national economy and security. Although most of our foreign trade cargo moves by sea, vessels of U.S. registry carry only about 5 percent by weight of the total. During the past year, the maritime industry had more than its normal share of problems. The American-flag merchant fleet continued to pass through a crucial transitional period as the remainder of the World War II built fleet was rapidly phased out. However, by the enactment of the Merchant Marine Act of 1970, the President and the Congress provided the tools for restoring the United States as a first-class maritime power. The achievements to date, under the President's new program, have been substantial.

The shipyards are meeting the challenge laid down by the President, making it possible to reduce the construction subsidy required to meet foreign competition by more than 10 percent, and contracts have been let to further the modernization of the American merchant fleet.

In the last 12 months, the Maritime Administration assisted a number of established shipping companies to modernize and convert their break-bulk fleets for containerized service. American President Lines and American Mail Line both signed contracts for fleet modernization to continue programs started in 1970. It may well be said that 1971 marked the beginning of the end of the break-bulk era in the merchant marine and clearly signaled a change to high-productivity ships. At the same time, 1971 saw a growing concentration on bulk carriers by American ship operators.

During the last fiscal year, a number of shipbuilding records were set. Construction contracts were signed for $390 million, the largest amount of commercial shipping in the Nation's history. This included $170 million in subsidy payments, the largest single-year subsidy since the inception of the program 35 years ago. The American shipbuilding industry ended the year with 55 merchant ships, aggregating 2.4 million deadweight tons, under construction or on order (the largest backlog of commercial tonnage in hand at the start of any year since 1958). El Paso Natural Gas announced its intention to build six liquified natural gas (LNG) tankers (more than $400 million of new ship construction) in American shipyards. This will be the largest single order ever placed in the United States for the building of commercial vessels.

This year orders continued for highly productive ships—for example, new barge-carrying tonnage for Central Gulf, Delta Line, and the Waterman Steamship Corp. which was added to the ranks of subsidized shipping firms.

Containerization and LASH (lighter aboard ship) are revolutionary cargo handling features of this new merchant vessel. The moving gantry system loads and unloads containerized cargo over the stern without requiring pierside space, resulting in faster transport and reduced costs and handling.

A new program was started for subsidized construction of 80,000-ton ore-bulk-oil (OBO) carriers and a 230,000-ton supertanker. In January 1972, Keystone Shipping signed contracts with National Steel for construction of three tankers. Shell International, which will charter these ships from Keystone Shipping, could have obtained comparable tonnage elsewhere; but in this highly competitive market, an American builder was able to compete successfully. This is the first time in modern history that a U.S. owner has been able to obtain long-term charters for American-flag operation in foreign trade. Prior to the 1970 Act, this would not have been possible.

During 1971, applications for the establishment of capital construction funds were approved for 45 companies. As these funds grow, they will provide a greatly expanded base for the industry to develop new fleets in the years ahead. It is generally agreed that the modern fleets of today exist almost entirely because of the ability of the merchant marine companies to set aside tax-deferred dollars for future shipbuilding.

With the great expansion thus indicated, a growing availability of capital funds for future building is foreseen. This has become most immediately apparent in the Great Lakes area where several companies have plans for the construction of 10 new dry-bulk carriers and seven smaller vessels and for major conversions of 17 existing bulk carriers. The estimated contract prices of these projects total $175 million. With most of the principal companies engaged in trade between the United States and its nonconterminous areas having now established reserve funds, it can be anticipated that programs will be underway within the next year to replace the old World War II built tonnage that has been serving Alaska, Hawaii, and Puerto Rico.

The 1970 Act also provided the use of the Title XI Mortgage Insurance for a widely expanded area of commercial marine-related equipment. In the past 12 months, some $322 million in privately placed vessel construction and mortgage loans have been guaranteed by the Government. This amount is 46 percent higher than that for the preceding 12-month period and represents the greatest volume of Title XI insurance activity since the inception of the program in 1938.

The mortgage commitments today are at the $1.3 billion level; an estimated $550 million is to be added in the year ahead. Without the additional $2 billion authorized by the 1970 Merchant Marine Act, this growth would not have been possible. During the last year, Title XI financing of large tug-barge systems and offshore drilling rigs was arranged for the first time. It should be noted that in both of these areas the United States holds a technological lead, and our maritime industry, by moving rapidly ahead, will be in a position to maintain a significant worldwide advantage.

An essential part of transportation considerations is harbor and channel development, a $9 million program of investigations, engineering, and research under the Corps of Engineers. It is part of a $309 million program of designing, constructing, improving, and maintaining harbors and waterways. In the coming year, coordinated studies will be made for about 90 locations to meet the needs of shipping, fishing, and recreational boating interests. Those of highest priority include regional navigation studies for the northern Atlantic, Gulf, and Pacific coasts, with emphasis on very large bulk carriers, and studies for extending the navigational season on the Great Lakes (see below) and improving connecting waterways.

The Maritime Administration research and development program was greatly enlarged and redirected in 1971 to assist in rejuvenating the U.S. merchant marine through technological innovations in ships and ship operations. Programs initiated in 1971 and 1972 will be carried into more advanced phases in 1973. In the shipyards, automated hardware for welding, steel-surface preparation and coating, material handling, and other operations will be developed and tested. Full-scale propulsion hardware will be readied for testing at sea under service conditions. Development continues on large cryogenic tanks to carry LNG and on ship design engineering for easy and economical handling of bulk commodities such as coal or ore in slurry form.

Also continuing is the engineering development of satellite navigation and communication systems and automated controls to improve the safety of ship operations by preventing collisions, accidents, and ocean pollution through catastrophic spills. Final tests of shipboard systems designed to prevent ship-generated oil pollution and full-scale testing of advanced ocean-going tug-barge systems have started. These projects are directed toward decreasing capital and maintenance costs through improved shipyard operations, design of more productive ships, and more efficient ship and shipping operations.

The first research center in the United States devoted specifically to improving commercial shipping operations was opened in 1971 at the Maritime Academy, Kings Point, N.Y. The principal functions of the National Maritime Research Center are to carry out research programs for the Mari-

time Administration, serving as a field test and evaluation unit where proposed improvements can be fully tested under simulated operating conditions before being recommended for installation aboard ships. It will also stimulate the transfer of technical information among the various segments of the industry.

As noted in chapter II, the ever-increasing volume of cargo moved into and out of the United States by sea demands continuing port and harbor expansion. At the same time, radically different types of ships demand increasingly sophisticated facilities. Ships of unprecedented size require water depths practically obtainable in only a few U.S. ports. Studies initiated by the Corps of Engineers in 1971 are focusing first on port and harbor facilities for bulk cargoes, but will look later at other cargo movements. The Maritime Administration, with whom these studies are being coordinated, has started design studies for deep-draft, offshore terminals.

To prevent disastrous collisions, groundings, and pollution from tanker spills, the Coast Guard is working toward improved ship design and construction standards and is developing all-weather harbor approach and harbor navigation systems. Development of light buoys and buoy-support systems is also being undertaken to provide more responsive and more economical aids to navigation. Progress is also being made in the surveillance and identification of ice distribution, type, features, and stresses by use of Side-Looking Airborne Radar (SLAR) and the penetrometer, the only proven technique for the airborne remote measurement of ice thickness.

In August 1971, the Department of Transportation awarded a contract to the Lockheed Shipbuilding & Construction Co. for the first new polar icebreaker to replace the aging *Wind*-class icebreakers. Funds for another icebreaker are included in the Fiscal Year 1973 budget. Polar icebreakers operated by the Coast Guard constitute the entire U.S. polar icebreaking fleet which is necessary for resupply of strategic outposts and the accommodation of scientific missions in these remote areas.

To improve winter navigation on the Great Lakes, the home port of the Coast Guard's polar icebreaker *Edisto* was changed from Boston to Milwaukee, Wis., in December 1971. Her icebreaking capabilities, added to those of the Coast Guard's Cutter *Mackinaw*, should go far toward increasing the flow of commerce on the Lakes.

Major Research Projects

It has long been recognized that the time and space scales of the oceans and atmosphere are such that they must be studied cooperatively, over large areas and long periods, in programs requiring funding, talent, and equipment far beyond those held by any single agency or nation. Recent advances in theory, numerical modeling, data management, and technology have encouraged the conduct of such investigations.

Now, in the decade of the 1970's, plans laid in the recent past are being transformed into an array of projects that range from studies of coastal ecology to global investigations of the atmosphere and ocean. And, just as emphasis has moved to the environment, so has experimental science. At all

The icebreaker, Edisto, *was transferred from Boston to the Great Lakes port of Milwaukee to assist the USCGC* Mackinaw, *W83, shown here freeing a car ferry, in the extension of the navigation season on the Great Lakes and St. Lawrence Seaway.*

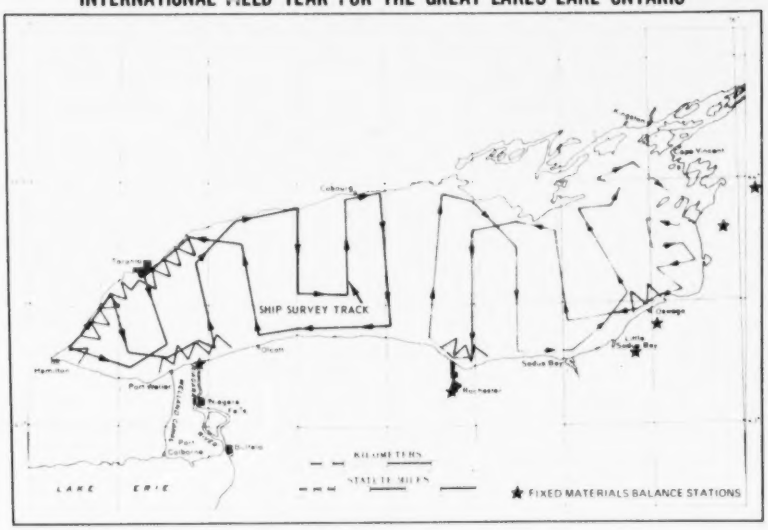
scales and in all scientific disciplines applied to the marine world, experiments are using the environment itself as a colossal laboratory and measuring life and physical processes when and where they occur.

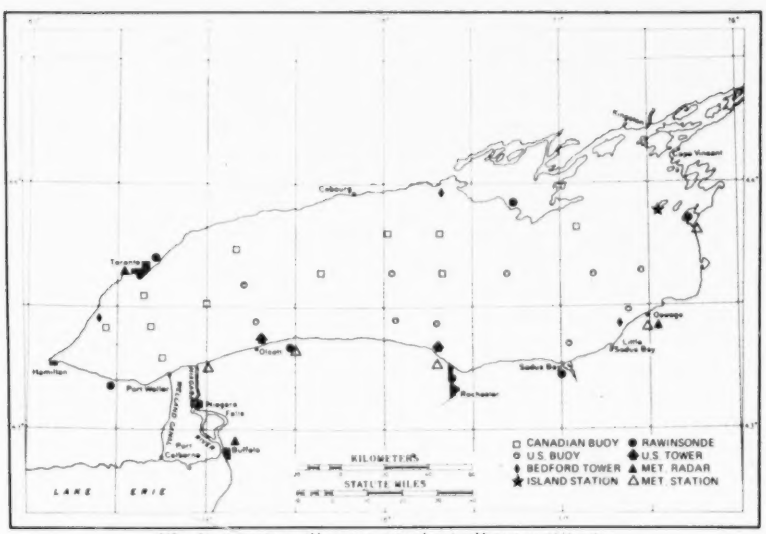
International Field Year for the Great Lakes (IFYGL)

The IFYGL is a program involving Federal, State, and Provincial agencies, universities, and private industrial organizations in the United States and Canada. Planning for this program has been in progress for several years as a result of initiatives by the National Research Council of Canada and by National Academy of Sciences of the United States, as part of the International Hydrological Decade Program. NOAA became the U.S. lead agency for IFYGL in October 1970. Other participating Federal agencies are the Air Force Weather Service, Army Corps of Engineers, BSFW, Coast Guard, EPA, Federal Aviation Administration (FAA), NASA, and NSF. The New York State Department of Environmental Conservation is also involved. International coordination is focused in a Joint (United States-Canada) Management Team.

The central objective of IFYGL is the development of a sound scientific basis for water resource management on the Great Lakes as an aid in solving problems of water quality, water quantity, and other environmentally sensitive operations. Lake Ontario and the Ontario Basin were selected as

INTERNATIONAL FIELD YEAR FOR THE GREAT LAKES-LAKE ONTARIO





TOP: Fixed stations will measure natural and pollutant constituents of waters emptying into the lake while ships, along track line, will measure amounts of these same constituents temperature and other parameters in the lake itself. Other stations in the St. Lawrence Seaway will take the same measurements of water leaving Lake Ontario.

BOTTOM: IFYGL observation system.

representative of physical characteristics typical of the Great Lakes and, more generally, as offering the opportunity for investigating typical water resource problems. A series of hydrological and limnological studies, as well as special investigations associated with the effects of ice and lake storms, will serve to meet management requirements for environmental factors pertinent to navigation, hydropower, public water supply, waste disposal, recreation, fish productivity, highway transportation, and the operation of port facilities.

Experimental projects are being undertaken in IFYGL to ascertain the large-scale processes important to Lake Ontario, for example, materials balance, heat balance, and terrestrial water balance. Experiments will also provide data and information on small-scale variability of operational parameters and related variables and on lake phenomena and address the total lake coastal regions and the Basin. Major projects are circulation-diffusion, chemistry and biology, fisheries, and lake-atmosphere boundary layer. While the experimental approach is the major emphasis in IFYGL, water resource management requires improved prediction of the environmental response to or effects upon management alternatives. Modeling and simulation projects are therefore included, and the multiyear analysis phase following the Field Year is of significance.

The joint United States-Canadian data-collection program scheduled to run from April 1, 1972, to March 31, 1973, is the most comprehensive yet planned for the Great Lakes in terms of network intensity in space and time, numbers and types of data-acquisition systems, and use of advanced data-acquisition systems. A U.S. field headquarters is being established at Rochester, N.Y., to deploy, operate, maintain, and support the major U.S. data-acquisition systems and for field data management activities. The Canadian Centre for Inland Waters (CCIW) is the focal point for Canadian field operations.

Five major and many supporting data-acquisition systems are being operated. Ship systems will measure lake physical, chemical, biological, and meteorological properties at predetermined stations and tracks, utilizing accurate DECCA navigation and various measurement devices, for example, electronic bathythermographs and sonar. Water samples will be obtained and processed at water analysis laboratories aboard the vessels and also at shore facilities. Canada will employ three major research vessels; the United States, two, plus many small vessels. Buoy, tower, and automatic meteorological stations will measure currents, water temperatures, water levels, and surface meteorological parameters. A buoy network of 11 Canadian and 10 American buoys is planned. Three calibrated weather radars will measure precipitation intensity over small-area elements and span the Lake and Basin every 10 minutes for the 12-month Field Year. Advanced rawinsonde systems will be released at frequent intervals from six stations around the Lake to make atmospheric soundings of wind, temperature, moisture, and pressure. Airborne instruments will measure vertical fluxes of heat, moisture, and momentum in the atmospheric boundary layer. Remote sensing observations of surface information, such as temperature and snowpack water content, will include multispectral and radiation measurements. Participating scientists will also use such systems at towers, wells, stream gages, and pro-

cedures to measure fish, benthos, phytoplankton, and zooplankton. It is anticipated not only that all the interlocking scientific programs now underway will yield better knowledge of the physical, chemical, and biological processes occurring in Lake Ontario, but that this knowledge will be useful in resolving water resource problems of Lake Ontario and other lakes.

Great Lakes-St. Lawrence Seaway Navigation Season Extension Demonstration

Under the Rivers and Harbors Act of 1970, the Corps of Engineers was assigned responsibility for implementing a 3-year cooperative program to extend the navigational season of the Great Lakes and the St. Lawrence Seaway. The Department of the Interior, AEC, EPA, Great Lakes Commission, Great Lakes Basin Commission, NASA, Coast Guard, Maritime Administration, NOAA, and the Corps have formed the Winter Navigation Board, with the International Joint Commission and Canada participating as observers. The Board has established an advisory group of industry, labor, and consumer representatives and concerned citizens to assure balanced consideration of all interests. The surrounding States make direct contributions to policies and programs through the Commissions in the Great Lakes area. The program will include: improving vessel construction techniques, navigation aids, and icebreaking technology to insure safe and economical merchant-vessel operations in ice-covered waters; and performing basic research on ice mechanics, structural design, and measurement techniques to improve present understanding of ice forces. It will also consider methods of reducing or preventing ice formation in critical areas and develop operating procedures and ice-control devices to improve operations during the navigation season.

In 1971, ice-control structures in the St. Lawrence Seaway were instrumented, and a broad environmental and ecological study program was developed. Ice-control devices were tested in the St. Marys River near Soo Locks and in the St. Lawrence River above the Eisenhower Lock; in 1972, mechanical methods for keeping harbors open will be tested, instrumentation will be added to a Great Lakes structure to measure the impact of ice forces, winter gates on the St. Marys River control structure will be tested, and contracts will be let for installing ice booms designed last year.

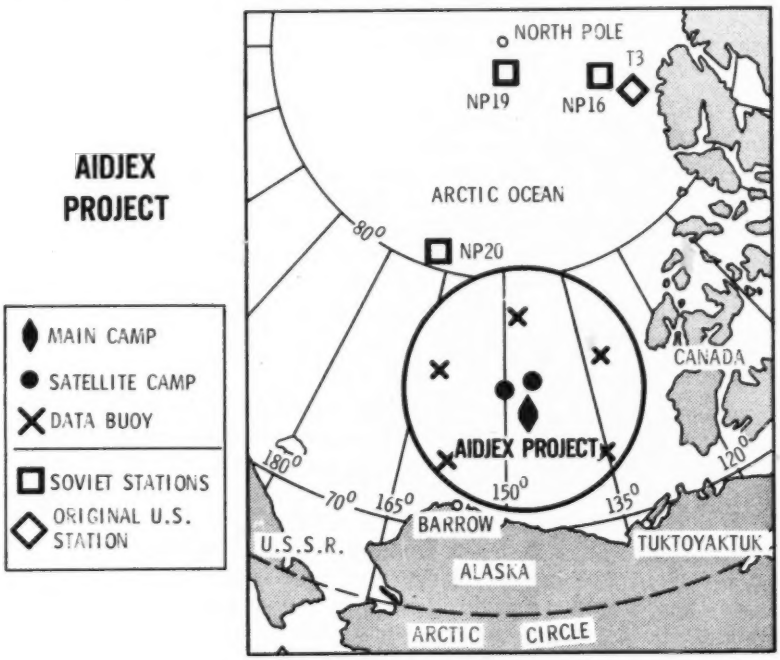
GARP Atlantic Tropical Experiment (GATE)

Scheduled for the summer of 1974, the GARP (Global Atmospheric Research Program) Atlantic Tropical Experiment (GATE) will be the first of a series of major observational experiments sponsored by the WMO and the International Council of Scientific Unions. The objectives of GATE are to study the structure and evolution of weather systems in the tropical eastern Atlantic and to assess the extent to which these tropical disturbances affect the behavior of the whole atmosphere. It is believed that tropical convective storms, besides being a dominant feature of weather in the Tropics, provide a strong driving force for the entire atmosphere and that they transport vast quantities of heat and moisture from the tropical oceans into the atmosphere at higher latitudes and, therefore, affect weather everywhere. First priority

has been given to the Tropical Experiment because so little is known of the behavior of tropical weather systems and how to incorporate them into global models.

From nations participating in GATE will come some 20 or more research vessels, in excess of 10 research aircraft, and automated data buoys to measure environmental processes in experimental areas involving tens of thousands of square miles of ocean surface and the vertical column from the sea bed to the stratosphere. Satellites will be a third type of data-gathering platform in GATE, with polar-orbiting and geostationary satellites contributing day and night images of weather and thermal patterns over the experimental area. The Global Telecommunications System, Regional and World Meteorological Centers, and World Data Centers will manage the huge collection of data expected from GATE, and a special GATE Data Center planned at Bracknell, England, will receive and integrate data destined for eventual archiving in World Data Centers.

Although the oceanographic component of GATE is not yet as well developed as the meteorological part, interest is increasing rapidly, and oceanographers have begun to formulate a program. The need is apparent, for example, for measurements that further define the heat budget of the upper oceanic layers and interactions across the air-sea boundary. U.S. participation in GATE is being coordinated by NOAA. The GATE oceanographic research program for the United States is being developed by the Ocean Affairs Board of the National Academy of Sciences.



Arctic Ice Dynamics Joint Experiment (AIDJEX)

The presence of sea ice interferes with the exchange of heat and moisture between ocean and atmosphere. Similarly, ice interferes with the influx of solar heat in the surface layers of the ocean. The extent of the interference depends upon how much of the polar sea is actually covered by ice and how much is exposed to the atmosphere through stress-caused cracks or leads in the ice. This, in turn, is determined by wind stress on the upper surface or the ice and water stress on the under surface.

Field observations of the percentage of open area in the ice have shown it varying from 1 to 10 percent over the years. If the reported values are real, the ocean-atmosphere coupling in the Arctic must experience changes which profoundly influence the strength and duration of outbreaks of polar air that sweep across oceans and continents.

Numerical models of sea-ice response to wind and water stress and of ocean-atmosphere energy exchange in the presence of different kinds and amounts of ice cover have been devised. The immediate goal of AIDJEX is to test and refine these models. The long-term goal of the project is a general model of ocean-atmosphere coupling for the northern ice ocean that fits smoothly with global ocean-atmosphere models being developed elsewhere.

Initiated as a joint United States-Canada program, international interest in AIDJEX is increasing and the project will probably expand to include several other nations. Japan has become a recent participant. In the United States, the effort of several Federal agencies is being coordinated by NSF and Navy.

The scientific plan, covering a 2-year period, includes the acquisition of time series meteorological, oceanographic, and ice dynamics data by manned stations in the field experimental area and by arctic SPAR buoys at unattended stations. Buoy data and buoy location will be monitored through a satellite relay by scientists at the University of Washington, where data will be processed and analyzed. A pilot project was successfully carried out in March 1971 on the Beaufort Sea ice west of M'Clure Strait at latitude 74° North. A similar pilot project, including three drifting manned stations, is now being conducted north of Pt. Barrow, Alaska.

Louisiana Coastal Ecology

In 1969, the Corps of Engineers began a study of fish and wildlife, and related ecological factors, in the Louisiana coastal zone in cooperation with the Department of the Interior, EPA, NOAA, the Wetlands Resource Center of Louisiana State University, and the State of Louisiana's Wildlife and Fisheries Commission, Department of Public Works, and Stream Control Commission. The study will measure physical, chemical, and biological processes of the estuarine environment and examine the influence of these factors on the living resources of the Louisiana coast.

During 1971, chemical and physical data were analyzed to establish area characteristics, to determine how and why these parameters change, and to set forth the present and probable future extent of environmental deterioration. The contributions of canals to land loss and wetlands deterioration

were also assessed. The major portion of this program, to be completed during 1972, will include the development of a pilot study of the Terrebonne Parish area to provide techniques for modifying existing improvements in the Louisiana coastal zone for hurricane protection, reduction of saltwater intrusion, preservation of fish and wildlife, prevention of coastal erosion, and enhancement of water quality.

Activities of the IOC

The Intergovernmental Oceanographic Commission (IOC) began its second decade under new statutes that substantially increased its authority and broadened its scope as the central coordinating point for marine science in the United Nations Organization. The IOC adopted new, more effective procedural rules and strengthened its ties with the United Nations Educational, Scientific, and Cultural Organization (UNESCO), Food and Agriculture Organization (FAO), World Meteorological Organization (WMO), and Inter-Governmental Maritime Consultative Organization (IMCO).

The IOC held its Seventh Biennial Session in Paris, France, from October 26 through November 5, 1971. The Session made significant progress on the development of the IOC's Long-term and Expanded Program of Oceanic Exploration and Research (LEPOR) and the International Decade of Ocean Exploration (IDOE). The Global Investigation of Pollution in the Marine Environment (GIPME) was established as a major project of IDOE and LEPOR. The Session also adopted seven additional projects of major importance for LEPOR: a study of upwelling, including ocean-atmosphere interaction; a survey of living resources; coastal ecology and mariculture; morphological charting of the sea floor; systematic geological and geophysical surveys of continental margins; river discharge of sediments and alongshore transport; and physical research related to the Integrated Global Ocean Station System (IGOSS). Lastly in this area, the Session strengthened the role of IDOE as the acceleration phase of LEPOR for the period from 1971 through 1980. As noted in chapter IV, the IOC has also taken the first steps toward IGOSS by planning a 1972 pilot project for the collection, exchange, and evaluation of bathythermograph data.

During 1971, the Commission, in cooperation with IMCO, completed preparation of a draft convention to clarify the legal status of ocean data-acquisition systems. In data exchange, the IOC adopted the interim standard international data inventory form (ROSCOP) for use in international cooperative programs and in national programs.

The IOC also informed the Intergovernmental Working Group on Monitoring preparing for the United Nations Conference on the Human Environment that it is willing to accept responsibilities for promoting, planning, and coordinating an international marine-pollution-monitoring program.

Developing countries were assisted last year in understanding and utilizing locally available ocean resources through the scientific endeavors of the IOC and the programs of resource utilization of the FAO and the United Nations Development Program. To this end, the United States, in conjunction with IOC, sponsored a training course for selected students from Latin America, Africa, and Asia. This AID-funded program, conducted by

NODC in cooperation with UNESCO, is designed to strengthen capabilities to acquire, process, and utilize information on ocean resources.

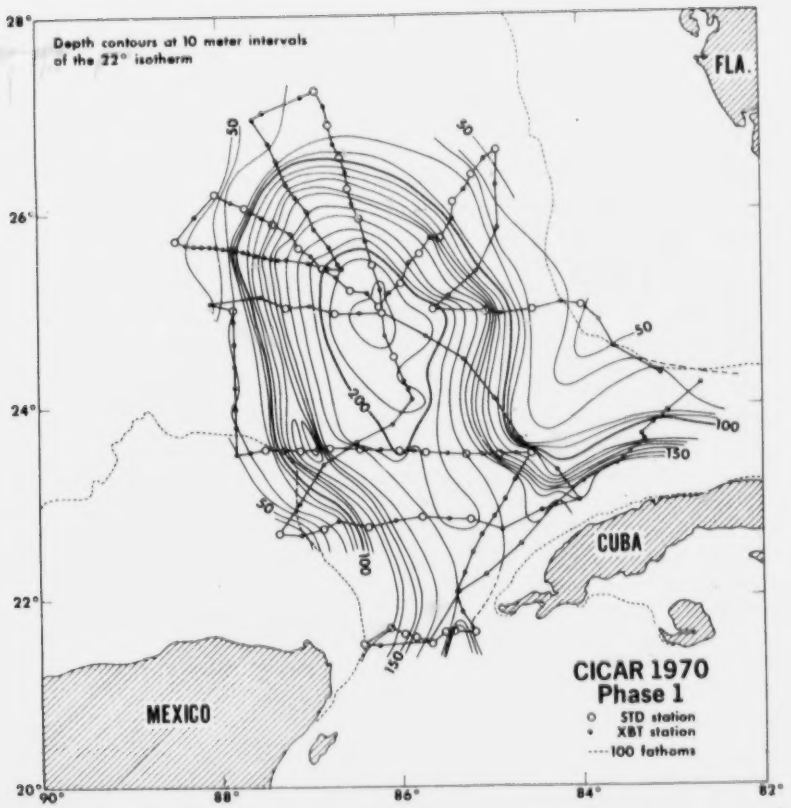
In a related program, not associated with the IOC, AID made up to $450,000 available in June 1971, to the Marine Science Project of the Organization of American States (OAS) Regional Development Program of Science and Technology. This grant was made through the Special Multilateral Fund as a special, unmatched, one-time contribution to upgrade the capabilities of four institutions under the Program to become regional marine science training centers, with the proviso that OAS assign to marine science training the highest priority for funding of new programs in their budget for 1971–72 and beyond. The AID contribution covers costs for equipment and related training services for regional purposes at marine institutions in Argentina, Colombia, Mexico, and Venezuela. Under this Program, the National Oceanographic Instrumentation Center is collaborating with the OAS to develop appropriate oceanographic equipment lists and related services, including the training necessary to insure that all equipment purchased under this Program remains in calibration and in operating condition for a reasonable length of time.

Planning began under the auspices of the Cooperative Investigation of the Northeast Central Atlantic (CINECA) for conducting two brief but intensive surveys of upwelling off the northwest coast of Africa in 1973. The United States also participated in the continuing Cooperative Investigations of the Mediterranean (CIM); the Smithsonian's Mediterranean Marine Sorting Center in Tunisia continued to function as the CIM Biological Center and cooperated with UNESCO in training area technicians in the fundamentals of evaluation of living marine resources.

The United States was also active in 1971 in the IOC Cooperative Investigation of the Caribbean and Adjacent Regions (CICAR), a 15-nation cooperative scientific effort completing its third year of field operations in the Gulf of Mexico and the Caribbean Sea. The overall scientific program is directed toward the developing and understanding of the physical oceanography, fisheries, marine biology, geology and geophysics, and meteorology of the Caribbean area.

Ships of many countries and from NOAA, the Coast Guard, USGS, and various American universities and institutions have been concentrating heavily in the southern Gulf of Mexico and Yucatan Channel area where significant advances have been made in the understanding of the complex circulation patterns. Work has also been accomplished in measuring the water movement through the Antillean passes at the eastern side of the Caribbean. A deep-sea tide gage program has emplaced bottom-mounted tide gages on the shallow banks in the western Caribbean as well as in water over 2 miles deep in the area south of Puerto Rico. Results have shown that an amphidromic point, as predicted, does indeed lie in that area.

In the fisheries portion of CICAR, considerable progress has been made on the standardization of sampling techniques and on the evaluation of stocks of larvae and juveniles of fish which might occur in commercial quantities. In marine geology and geophysics, major work has been carried out by the United States and United Kingdom and, to a lesser extent, Mexico and Venezuela. This work has been aimed at defining the geological and tec-



CICAR, the Cooperative Investigation of the Caribbean and Adjacent Regions, has begun to produce significant new data. Here, data from a CICAR cruise by NOAA's Discoverer *reveal characteristics of the Gulf "loop current" between the Yucatan Channel and the Florida Straits.*

tonic framework for the Avis Ridge, the Lesser Antilles Arc, and the southeastern Caribbean area where the boundaries of crustal plates make the area particularly significant from a scientific point of view. Meteorological work has concentrated primarily in standardizing observations aboard ships taking part in the operations.

International Decade of Ocean Exploration

The IDOE program in the United States is planned, managed, and supported by NSF as part of the U.S. contribution to the Long-Term and Expanded Program of Ocean Exploration and Research adopted by the IOC in 1969. The initial funding year for the U.S. IDOE program was Fiscal Year 1971.

The NSF Office of the International Decade of Ocean Exploration sup-

ports U.S. participation, both Federal and non-Federal, in selected major oceanographic research efforts that will contribute to better understanding, preservation, and utilization of the global ocean for the benefit of the United States and other nations. Coordination with governmental agencies is achieved through the Interagency Decade Planning Group, and nongovernmental coordination is provided by panels of the National Academies of Sciences and Engineering.

The IDOE program supports large research efforts to: determine the quality of the ocean environment through accelerated scientific observations of the ocean's natural state, evaluate the impact of man's activity on that environment, and establish a scientific basis for corrective actions necessary to preserve the ocean environment; provide the scientific basis needed to improve environmental forecasting; assess the sea floor for its resource potential; provide the basic scientific knowledge of biological processes necessary to intelligently utilize living marine resources; and improve the scientific framework necessary to reach sound international agreements on man's uses of the oceans and the resources located therein.

To insure that data and results of IDOE programs are available to the entire scientific world, NSF supports NOAA's Environmental Data Service (EDS) for data handling and its National Oceanographic Instrumentation Center (NOIC) for testing, evaluating, and calibrating selected prototype instruments used by IDOE projects.

International scientific coordination has been provided by the Scientific Committee on Oceanic Research (SCOR) of the International Council of Scientific Unions and an IOC Advisory Body. As part of the IDOE program, the NSF assists these international bodies to bring members of the international scientific community together to consider and plan projects. Direct scientist-to-scientist communication continues to be very influential in formulating sound international IDOE research proposals.

Projects designed to meet IDOE program objectives fall into four major categories: Environmental quality, environmental forecasting, seabed assessment, and living resources.

Environmental Quality

The Geochemical Ocean Section Study (GEOSECS) research team will make detailed measurements of oceanic characteristics along Arctic and Antarctic longitudinal sections in the Atlantic and Pacific at all depths to provide, for the first time, a set of physical and chemical data measured on identical water samples. The studies will establish geochemical baselines for long-term reference and provide input for quantitative studies of oceanic mixing and for descriptive oceanic circulation models. The multiyear project involves 13 U.S. laboratories as well as scientists, laboratories, and ships from Canada, France, the Federal Republic of Germany, India, Italy, and Japan. The U.S. portion of GEOSECS will operate from the Woods Hole Oceanographic Institution in the Atlantic and the Scripps Institution of Oceanography in the Pacific. The past year has been devoted to preparing the shipboard sampling and analysis program for the 9-month expedition scheduled to start in the Atlantic in July 1972. Shore laboratories have been built

and equipped, special shipboard instruments have been developed, and specialized technicians hired and trained.

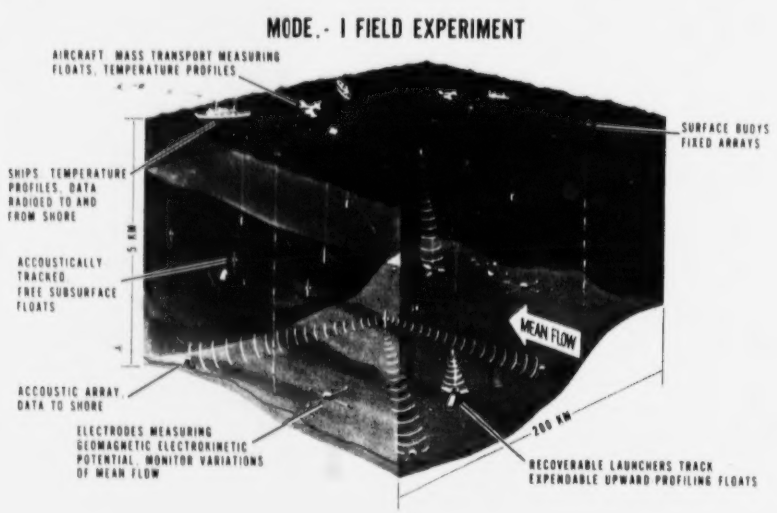
During 1971, a concerted regional baseline study was made to determine current levels of suspected pollutants in the Atlantic and Pacific Oceans, the Gulf of Mexico, and the Caribbean Sea. Fish plankton, sediments, and water were analyzed for heavy metals, chlorinated hydrocarbons, and petroleum-derived hydrocarbons. The program has involved scientists from 17 domestic universities, nonprofit and agency laboratories, as well as several laboratories from abroad. The analytical result will be evaluated and interpreted at an international NSF/IDOE-sponsored conference in May 1972 to provide guidance for future marine pollution research.

Research on processes responsible for the transfer of pollutants into and within the marine environment was started during the past year; it is a necessary precursor to studies on the effects and fates of pollutants in the ocean.

Environmental Forecasting

Scientists in the Mid-Ocean Dynamics Experiment (MODE–I) will attempt to describe and to formulate numerical models of medium-dynamic processes, such as geostrophic eddies, and to understand their role in ocean circulation and global climate. Over 25 theoreticians and field experimenters from 10 universities, Government laboratories, and the Woods Hole Oceanographic Institution in the United States and from the National Institute of Oceanography and Cambridge University in England are participating.

During the past year, they have concentrated on the theoretical design of the Experiment and the development and procurement of instruments for determining the water movement and density field in an experimental region south of Bermuda approximately 200 kilometers across and 5 kilometers deep. The research fleet will consist of one British and three American vessels.


MODE - I FIELD EXPERIMENT
AIRCRAFT, MASS TRANSPORT MEASURING FLOATS, TEMPERATURE PROFILES
SURFACE BUOYS FIXED ARRAYS
SHIPS, TEMPERATURE PROFILES, DATA RADIOED TO AND FROM SHORE
5 KM
ACCOUSTICALLY TRACKED FREE SUBSURFACE FLOATS
MEAN FLOW
ACCOUSTIC ARRAY, DATA TO SHORE
ELECTRODES MEASURING GEOMAGNETIC ELECTROKINETIC POTENTIAL, MONITOR VARIATIONS OF MEAN FLOW
200 KM
RECOVERABLE LAUNCHERS TRACK EXPENDABLE UPWARD PROFILING FLOATS

The field projects began with several small arrays of moored instruments in November 1971. These will be followed by tests and trials of new instrumentation during 1972, culminating in the intensive MODE–I experiment from March through June of 1973. In addition to bottom pressure gages, inverted echo sounders, and geomagnetic electric-field recorders, instrumentation will consist of fixed-moored arrays for recording current and temperature, free-floating instruments situated at about the 1,200-meter depth and tracked acoustically, and vertical-profiling instruments launched from ships and aircraft to measure salinity, temperature, and horizontal currents.

Meteorological and physical oceanographic studies of coastal upwelling were initiated last year. The Coastal Upwelling Experiment (CUE) investigators have concentrated on strengthening theoretical and numerical models and on preparing instruments required for the 1972 field study. The study, carefully designed to evaluate existing theoretical and numerical upwelling models, will take place in a well-studied upwelling area off the Oregon coast.

Researchers are doing detailed stratigraphic analyses on existing deep-sea cores in a Paleo-Oceanography Study started last year. The objectives are to determine, in detail, oceanic and climatic fluctuation that will help evaluate man's impact on observed environmental changes.

Seabed Assessment

A reconnaissance-scale geophysical survey of the stratigraphy and structure of the west coast of Africa, one of the world's major unexplored wide continental margins, began during the past year. The project involves oceanographic laboratories from the United States, Europe, and Africa. The 4-year project includes two 6-month field expeditions spread over 2 years. The first field effort, after 1 year of preparation, started in January 1972. Similar studies off the east coast of South America are proposed as part of the program during 1972.

Surveys of rift valleys and trenches were initiated in 1971 to investigate processes responsible for producing heavy mineral concentrations along mid-oceanic ridges and for assessing the potential of deep oceanic trenches for disposal of manmade waste. A study of the Nasca lithospheric plate off the west coast of Peru focused on its active boundaries, which include the rift valley of the East Pacific Rise and the Peru-Chile Trench. The major effort was begun by two U.S. university and Government laboratories with assistance from South American scientists. It has been expanded to include an examination by Scripps Institution of Oceanography of the extension of the East Pacific Rise in the Gulf of California.

Living Resources

Programs in this area will concentrate on the study of marine ecosystems. Although no specific projects were started last year, research efforts were supported under other IDOE programs. The CUE, of major importance to the living resources investigation, will be expanded in 1972 to support comprehensive physical, chemical, and biological research of the total upwelling ecosystem. Examination of the more complex marine ecological systems, such

as coral reefs, is another essential long-term component of the living resources program, and preliminary work aimed at program definition was initiated last year.

North Pacific Experiment (NORPAX)

Convergence of several recent advances in the state of the art of marine science and technology has encouraged a number of the leading U.S. oceanographers to formulate NORPAX, an extensive experiment in the North Pacific. Among these advances are demonstrations of data buoy performance and reliability during the past few years in the North Pacific pilot study.

Hypotheses have been formulated describing the behavior of the circulation of the North Pacific Ocean and its changing influence over the climate and weather of North America. To test these hypotheses, the ongoing North Pacific study, sponsored by the Navy, is being expanded in a joint supported effort with IDOE to cover key locations over the entire North Pacific Ocean.

Several more large buoys—the so-called monster buoys—will join the two presently deployed and operating in the North Pacific. A number of smaller buoys will be moored in a cluster surrounding each monster buoy at a radius of several hundred kilometers. Their data will be transmitted to the shore station on the Scripps campus and ultimately archived in the NCC at Asheville, N.C., and in the NODC at Washington. In addition, data from transoceanic commercial jet aircraft, satellites, island stations, ships, and historical records will be assembled at the Scripps' NORPAX facility for use by participating scientists.

The North Pacific study, now in its third year, is expected to continue for another decade. From this Experiment may come knowledge of the oceanic events that accompany persistent changes in weather and climate, and numerical models that improve the accuracy of long-range weather and marine forecasts.

APPENDIXES

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAM, FISCAL YEARS 1971, 1972, AND 1973

Appendix A–1—Federal Marine Science Program [a] by Department and Independent Agency

[In millions of dollars]

	Estimated Fiscal Year		
	1971	1972	1973
Department of Defense	231.2	239.1	252.4
Department of Commerce [b]	139.3	160.9	194.9
National Science Foundation	49.4	66.8	68.9
Department of Transportation	34.3	56.2	53.3
Department of the Interior	27.5	34.9	41.7
Environmental Protection Agency	12.2	21.9	26.4
Department of State	8.3	9.4	9.6
Department of Health, Education, and Welfare	6.0	6.6	7.7
Atomic Energy Commission	7.7	7.8	6.7
National Aeronautics and Space Administration	3.3	4.2	6.4
Smithsonian Institution	2.8	3.0	3.9
Total	522.0	610.8	671.9

[a] Many programs of the Departments of Defense, Commerce, the Interior, and Transportation and other agencies closely related to marine science are not included.

[b] Program elements of the Departments of Defense, the Interior, and Transportation and the National Science Foundation were transferred to the Department of Commerce, National Oceanic and Atmospheric Administration, under Reorganization Plan No. 4 of 1970 and Executive Order No. 11564.

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAM, FISCAL YEARS 1971, 1972, AND 1973—Continued

Appendix A-2—Federal Marine Science Program[a] by Major Purpose—Summary

[In millions of dollars]

	Estimated Fiscal Year		
	1971	1972	1973
1. International Cooperation and Collaboration	8.8	9.5	9.8
2. National Security	102.0	94.6	97.2
3. Fishery Development and Sea Food Technology	45.5	48.7	61.7
4. Transportation	37.3	63.7	69.7
5. Development and Conservation of the Coastal Zone	48.9	77.3	93.7
6. Health	5.9	6.5	7.6
7. Nonliving Resources	11.4	16.5	20.2
8. Oceanographic Research	101.5	123.8	126.3
9. Education	6.9	7.6	8.7
10. Environmental Observation and Prediction	43.0	41.4	42.7
11. Ocean Exploration, Mapping, Charting, and Geodesy	79.1	89.0	100.6
12. General-Purpose Ocean Engineering	29.1	28.9	29.8
13. National Data Centers	3.1	3.3	3.9
Total	522.5	610.8	671.9

[a] Many programs of the Departments of Defense, Commerce, the Interior, and Transportation and other agencies closely related to marine science are not included.

Appendix A-3—Federal Marine Science Program[a] by Major Purpose—Detail by Subpurpose and Agency

[In millions of dollars]

	Estimated Fiscal Year		
	1971	1972	1973
1. International Cooperation and Collaboration	8.8	9.5	[b]9.8
a. State Department	(8.8)	(9.4)	(9.6)
(1) Contributions to international organizations for marine science program activities	5.8	6.2	[c]6.3
(2) International fisheries commissions (U.S. share)	2.5	3.1	3.3
(3) Agency for International Development	0.5	0.1	0.0
b. National Science Foundation	(0.0)	(0.1)	(0.2)
(1) Support of international activities	0.0	0.1	0.2

See footnotes at end of table.

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAM, FISCAL YEARS 1971, 1972, AND 1973—Continued

Appendix A-3—Federal Marine Science Program [c] by Major Purpose—Detail by Subpurpose and Agency—Continued

[In millions of dollars]

	Estimated Fiscal Year		
	1971	1972	1973
2. National Security	102.0	94.6	97.2
a. Department of Defense [d]	(102.0)	(94.6)	(97.2)
(1) Problem oriented surveys for defense systems	18.8	19.8	20.4
(2) Marine science and technology in support of specific defense systems	36.4	38.6	42.3
(3) Undersea search, rescue, and recovery	31.6	27.8	26.9
(4) Instrumentation Center	0.4	0.0	0.0
(5) Capital investment for ship construction	11.1	1.4	0.4
(6) Advanced surface platforms	3.7	7.0	7.2
3. Fishery Development and Sea Food Technology	45.5	48.7	61.7
a. Department of Commerce [e]	(45.5)	(48.7)	(61.7)
(1) Fishery resources assessment, development, and management	31.2	32.7	44.7
(2) Technical and economic assistance to the commercial fishing industry	12.1	13.7	14.5
(3) Fish protein concentrate	2.2	2.3	2.5
4. Transportation	37.3	63.7	69.7
a. Department of Commerce	(20.7)	(23.8)	(30.0)
(1) Maritime science and technology	6.5	8.8	6.2
(2) Shipping economics and requirements	3.5	1.2	1.0
(3) Advanced ship engineering and development	7.7	7.1	9.7
(4) Improvements in ship operations and shipping systems	3.0	6.7	13.1
b. Department of Defense	(5.4)	(6.0)	(9.0)
(1) Channel and harbor development	5.4	6.0	9.0
c. Department of Transportation	(11.2)	(33.9)	(30.7)
(1) Search and rescue	1.6	2.2	2.4
(2) Aids to navigation	1.6	3.1	3.6
(3) Merchant marine safety	0.9	1.6	1.1
(4) Oceanography, meteorology, and polar operations	0.9	6.1	9.4
(5) Marine law enforcement	5.9	20.3	13.6
(6) Boating safety	0.3	0.6	0.6

See footnotes at end of table.

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAM, FISCAL YEARS 1971, 1972, AND 1973—Continued

Appendix A-3—Federal Marine Science Program by Major Purpose—Detail by Subpurpose and Agency—Continued

[In millions of dollars]

	Estimated Fiscal Year		
	1971	1972	1973
5. Development and Conservation of the Coastal Zone	48.9	77.3	93.7
a. Shore stabilization and protection	(3.2)	(3.5)	(6.0)
(1) Department of Defense	((3.2))	((3.5))	((6.0))
(a) Beach erosion control and hurricane stormsurge protection	3.2	3.5	6.0
b. Marine pollution management	(17.1)	(40.8)	(50.6)
(1) Department of Defense	((2.9))	((15.4))	((18.2))
(a) Pollution and flushing of bays, estuaries, and the Great Lakes	2.9	15.4	18.2
(2) Environmental Protection Agency	((12.2))	((21.9))	((26.4))
(a) Water quality enhancement	12.2	21.9	26.4
(3) Department of Commerce *	((0.8))	((1.2))	((1.6))
(a) Water quality enhancement	0.8	1.2	1.6
(4) National Science Foundation	((1.2))	((2.3))	((4.4))
(a) Regional environmental systems research	1.2	2.0	3.9
(b) Environmental aspects of trace contaminants	0.0	0.3	0.5
c. Recreation and conservation	(28.6)	(33.0)	(37.1)
(1) Department of Defense	((2.0))	((3.0))	((4.0))
(a) Recreational beaches and small-craft harbors	2.0	3.0	4.0
(2) Department of the Interior	((17.2))	((19.8))	((23.0))
(a) Planning for acquisition of marine-based recreational areas	0.1	0.1	0.1
(b) Development of marine areas for recreation	4.7	5.2	6.8
(c) Conservation of marine locales, gamefish, and wildlife	12.4	14.5	16.1
(3) Department of Transportation	((9.4))	((10.2))	((10.1))
(a) Search and rescue	0.5	0.1	0.0
(b) Enforcement of fish treaties	8.9	10.1	10.1

See footnotes at end of table.

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAM, FISCAL YEARS 1971, 1972, AND 1973—Continued

Appendix A-3—Federal Marine Science Program [a] by Major Purpose—Detail by Subpurpose and Agency—Continued

[In millions of dollars]

	Estimated Fiscal Year		
	1971	1972	1973
6. Health	[f] 5.9	6.5	7.6
a. Department of Health, Education, and Welfare		(6.5)	(7.6)
(1) Shellfish sanitation		1.1	1.4
(2) Fish inspection, regulatory		2.4	3.3
(3) Microbiology and biotoxins		0.1	0.2
(4) Chemistry of fish products		0.6	0.7
(5) Fish product standards		0.1	0.1
(6) Research grants		0.2	0.2
(7) Use of marine life in biomedical research		2.0	1.7
7. Nonliving Resources	11.4	16.5	20.2
a. Department of the Interior	(10.3)	(15.1)	(18.7)
(1) Geologic investigations and resources appraisal	2.5	5.0	7.0
(2) Marine source and interrelation for supply of freshwater	4.1	4.6	5.2
(3) Leasing and management of mineral resources	3.7	5.5	6.5
b. Department of Commerce [e]	(0.9)	(1.2)	(1.3)
(1) Marine mining	0.9	1.2	1.3
c. Department of Defense	(0.2)	(0.2)	(0.2)
(1) Beach-fill investigation	0.2	0.2	0.2
8. Oceanographic Research	101.5	123.8	126.3
a. Department of Defense	32.1	33.4	33.2
b. Department of Commerce	11.9	16.9	18.9
c. National Science Foundation	46.4	62.6	62.5
d. Department of Transportation	3.0	2.5	2.5
e. Smithsonian Institution	2.4	2.5	3.2
f. Atomic Energy Commission	5.7	5.9	6.0
9. Education	6.9	7.6	8.7
a. Department of Defense	1.5	1.3	1.3
b. Department of Commerce	3.2	4.1	5.2
c. National Science Foundation	1.8	1.8	1.8
d. Department of Health, Education, and Welfare	0.1	0.1	0.1
e. Department of Transportation	0.3	0.3	0.3

See footnotes at end of table.

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAM, FISCAL YEARS 1971, 1972, AND 1973—Continued

Appendix A–3—Federal Marine Science Program [a] by Major Purpose—Detail by Subpurpose and Agency—Continued

[In millions of dollars]

	Estimated Fiscal Year		
	1971	1972	1973
10. Environmental Observation and Prediction	43.0	41.4	42.7
a. Department of Defense	17.8	14.3	12.5
b. Department of Commerce	12.4	15.5	18.6
c. Atomic Energy Commission	0.6	0.5	0.0
d. Department of Transportation	10.4	9.3	9.7
e. National Aeronautics and Space Administration	1.8	1.8	1.9
11. Ocean Exploration, Mapping, Charting, and Geodesy	79.1	89.0	100.6
a. Department of Defense	52.0	55.5	58.2
b. Department of Commerce [g]	25.6	31.1	37.9
c. National Aeronautics and Space Administration	1.5	2.4	4.5
12. General-Purpose Ocean Engineering	29.1	28.9	29.8
a. Department of Defense	12.1	11.9	12.6
b. Atomic Energy Commission	1.4	1.4	0.7
c. Department of Commerce	(15.6)	(15.6)	(16.5)
(1) Data buoy systems [h]	13.0	13.0	13.8
(2) National Oceanographic [g] Instrumentation Center	2.6	2.6	2.7
13. National Data Centers	3.1	3.3	3.9
a. Department of Commerce	(2.7)	(2.8)	(3.2)
(1) National Oceanographic Data Center [i]	2.4	2.5	2.9
(2) Great Lakes Center [g]	0.2	0.2	0.2
(3) National Climatic Center	0.1	0.1	0.1
b. Smithsonian Institution	(0.4)	(0.5)	(0.7)
(1) Smithsonian Oceanographic Sorting Center	0.2	0.3	0.5
(2) Mediterranean Marine Sorting Center	0.2	0.2	0.2

[a] Many programs of the Departments of Defense, Commerce, the Interior, and Transportation and other agencies closely related to marine science are not included.

[b] Any comparison between the figures for Fiscal Years 1972 and 1973 should also consider the effective devaluation of the U.S. dollar because a large part of these funds are converted into foreign currencies.

[c] It should be noted that certain international agencies (e.g., the United Nations Development Fund) have not yet completed the allocation of their funds for Fiscal Year 1973. Therefore, it is possible that this figure will increase by 0.2 or 0.3.

[d] Except for Corps of Engineers civil works programs all Department of Defense funds relate to national security, although some appear in categories which are related to other national goals.

[e] Funds for the support of this program were listed under the Department of the Interior through Fiscal Year 1971.

[f] Subpurposes redefined after Fiscal Year 1971.

[g] Funds for the support of the Lake Survey, the Great Lakes Center, and the National Oceanographic Instrumentation Center were listed under the Department of Defense through Fiscal Year 1971.

[h] Funds for the support of the National Data Buoy Project were listed under the Department of Transportation through Fiscal Year 1971.

[i] Funds for the support of the National Oceanographic Data Center were included in the previous programs of the Departments of Defense, Transportation, the Interior, Health, Education, and Welfare, Commerce, the National Science Foundation, and the Atomic Energy Commission.

APPENDIX B—FEDERAL MARINE SCIENCE ACTIVITIES BY AGENCY

Agency	Mission
Department of Defense (Navy; Advanced Research Projects Agency; Army Corps of Engineers)	All phases of oceanography relating to national security; naval technology, ocean charting, and forecasting; civilian responsibilities: navigation, shore protection, and flood protection in the coastal zones and Great Lakes; harbor and coastal development, restoration, environmental studies, engineering development, and regulatory activities for the protection of marine environmental quality; lead responsibility for the Chesapeake Bay studies.
Department of Commerce (National Oceanic and Atmospheric Administration; Maritime Administration)	Environmental studies and engineering development for the protection of marine environmental quality; management, conservation, and development of living marine resources; identification and development of technology for evaluation and extraction of marine minerals; lead responsibility for air-sea interaction program and marine environmental observation and prediction program; advisory services including tsunami and hurricane warning; lead responsibility for marine charting and mapping of Great Lakes, coastal, and deep-ocean waters including geodesy and data storage; Sea Grant colleges and programs; National Oceanographic Data Center; National Oceanographic Instrumentation Center; National Climatic Center; National Geophysical Data Center; development of data buoys; research on ship design, shipbuilding, and ship operations; marine transportation and port systems.
National Science Foundation	Basic and applications-oriented oceanographic research; support of academic oceanography; lead responsibility for polar research; the International Decade of Ocean Exploration and facilities and ship support; and the Ocean Sediment Coring Program of the deep-sea drilling project.
Department of Transportation (Coast Guard; Office of the Secretary)	Safety and protection of life and property in port and at sea; delineation and prediction of ice masses; navigation aids; oceanographic and meteorological observations; transport systems analysis and planning; and environmental studies, engineering development, and regulatory activities for the protection of marine environmental quality and enforcement of fishery treaties.

APPENDIX B—FEDERAL MARINE SCIENCE ACTIVITIES BY AGENCY—Continued

Agency	Mission
Department of the Interior (Geological Survey; Bureau of Sport Fisheries and Wildlife; Bureau of Mines; Bureau of Land Management; National Park Service; Bureau of Outdoor Recreation; Office of Saline Water)	Geological and geophysical studies and mineral resources appraisal of continental shelves; management, conservation, and development of marine mineral resources; acquisition, preservation, and development of coastal areas; identification of sources and interrelationships for supply of fresh water; and environmental quality.
Environmental Protection Agency	Environmental studies, engineering development, and regulatory activities for the protection of marine environmental quality.
Department of State (Agency for International Development)	International ocean affairs policy; negotiations with foreign governments on international ocean affairs problems; participation in international organizations; support of international fisheries commissions. Foreign assistance and food resources for developing nations.
Department of Health, Education, and Welfare (Public Health Service; Office of Education; Food and Drug Administration)	Human health, healthfulness of food, biomedical research, and support of education.
Atomic Energy Commission	Radioactivity in the marine environment; development of marine nuclear technology.
National Aeronautics and Space Administration	Feasibility, design, and engineering of spacecraft and sensors for ocean observations.
Smithsonian Institution	Systematics and ecology of marine organisms including sampling, sorting, identification, research, curation, and data management; investigations of biological and geological factors of oceanic environment.

APPENDIX C—ESTABLISHMENT OF NATIONAL ADVISORY COMMITTEE ON THE OCEANS AND ATMOSPHERE

(Public Law 92–125 92d Cong., H.R. 2587 Aug. 16, 1971)

AN ACT to establish the National Advisory Committee on the Oceans and Atmosphere.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, There is hereby established a committee of twenty-five members to be known as the National Advisory Committee on Oceans and Atmosphere (hereafter referred to in this Act as the "Advisory Committee").

SEC. 2. (a) The members of the Advisory Committee, who may not be full-time officers or employees of the United States, shall be appointed by the President and shall be drawn from State and local government, industry, science, and other appropriate areas.

(b) Except as provided in subsections (c) and (d), members shall be appointed for terms of three years.

(c) Of the members first appointed, as designated by the President at the time of appointment—

(1) nine shall be appointed for a term of one year,

(2) eight shall be appointed for a term of two years, and

(3) eight shall be appointed for a term of three years.

(d) Any member appointed to fill a vacancy occurring prior to the expiration of the term for which his predecessor was appointed shall be appointed only for the remainder of such term. A member may serve after the expiration of his term until his successor has taken office.

(e) The President shall designate one of the members of the Advisory Committee as the Chairman and one of the members as the Vice Chairman. The Vice Chairman shall act as Chairman in the absence or incapacity of, or in the event of a vacancy in the office of, the Chairman.

SEC. 3. Each department and agency of the Federal Government concerned with marine and atmospheric matters shall designate a senior policy official to participate as observer in the work of the Advisory Committee and to offer necessary assistance.

SEC. 4. The Advisory Committee shall (1) undertake a continuing review of the progress of the marine and atmospheric science and service programs of the United States, and (2) advise the Secretary of Commerce with respect to the carrying out of the purposes of the National Oceanic and Atmospheric Administration. The Advisory Committee shall submit a comprehensive annual report to the President and to the Congress setting forth an overall assessment of the status of the Nation's marine and atmospheric activities and shall submit such other reports as may from time to time be

requested by the President. Each such report shall be submitted to the Secretary of Commerce who shall, within 90 days after receipt thereof, transmit copies to the President and to the Congress, with his comments and recommendations. The comprehensive annual report required herein shall be submitted on or before June 30 of each year, beginning June 30, 1972.

SEC. 5. Members of the Advisory Committee shall, while serving on business of the Committee, be entitled to receive compensation at rates not to exceed $100 per diem, including traveltime, and while so serving away from their homes or regular places of business they may be allowed travel expenses, including per diem in lieu of subsistence, in the same manner as the expenses authorized by section 5703(b) of title 5, United States Code, for persons in Government service employed intermittently.

SEC. 6. The Secretary of Commerce shall make available to the Advisory Committee such staff, information, personnel and administrative services and assistance as it may reasonably require to carry out its activities. The Advisory Committee is authorized to request from any department, agency, or independent instrumentality of the Federal Government any information and assistance it deems necessary to carry out its functions under this Act; and each such department, agency, and instrumentality is authorized to cooperate with the Advisory Committee and, to the extent permitted by law, to furnish such information and assistance to the Advisory Committee upon request made by its Chairman, without reimbursement for such services and assistance.

SEC. 7. There is hereby authorized to be appropriated to the Secretary of Commerce $200,000 for the fiscal year ending June 30, 1972, and each succeeding fiscal year to carry out the purposes of this Act.

Approved August 16, 1971.

Legislative history:
House Report No. 92–201 (Comm. on Merchant Marine and Fisheries).
Senate Report No. 92–333 (Comm. on Commerce).
Congressional Record, Vol. 117 (1971):
May 17, considered and passed House.
Aug. 2, considered and passed Senate, amended.
Aug. 5, House concurred in Senate amendments.

NATIONAL ADVISORY COMMITTEE ON OCEANS AND ATMOSPHERE MEMBERSHIP

Dr. William A. Nierenberg, Chairman—Scripps Institution of Oceanography
Dr. William J. Hargis, Jr., Vice Chairman—Virginia Institute of Marine Science
Mr. Charles F. Baird—International Nickel Company
Dr. Werner A. Baum—University of Rhode Island
Dr. Wayne V. Burt—Oregon State University
Dr. John C. Calhoun, Jr.—Texas A&M University
Mr. William D. Carey—A. D. Little Corporation
Dr. Dayton H. Clewell—Mobil Oil Corporation
Dr. John P. Craven—University of Hawaii
Dr. Charles L. Drake—Dartmouth College
Mr. Thomas A. Fulham—Suffolk University
Brig. Gen. Jos. J. George, USAF (retired)—Eastern Airlines
Mr. Gilbert M. Grosvenor—National Geographic Society
Dr. Francis S. Johnson—University of Texas, Dallas
Dr. Ralph A. MacMullan—Department of Natural Resources, Michigan
Dr. Thomas F. Malone—University of Connecticut

Mr. O. William Moody, Jr.—AFL–CIO
Mr. Mark Morton—General Electric Company
Mr. John J. Royal—Fishermen and Allied Workers Union
Dr. Julius A. Stratton—Ford Foundation
Dr. Verner E. Suomi—University of Wisconsin
Hon. Clement Tillion—Alaska State Legislature
Dr. Myron Tribus—Xerox Corporation
Rear Adm. Odale D. Waters, Jr., USN (retired)—Florida Institute of Technology
Dr. Edward Wenk, Jr.—University of Washington

APPENDIX D—INTERAGENCY COMMITTEE ON MARINE SCIENCE AND ENGINEERING OF THE FEDERAL COUNCIL FOR SCIENCE AND TECHNOLOGY

In recognition of the need for a continuing interagency mechanism for the coordination of marine sciences and engineering, the Chairman of the Federal Council for Science and Technology hereby establishes an Interagency Committee on Marine Science and Engineering under the auspices of the Federal Council for Science and Technology.

1. Purpose

The purpose of the Committee will be to ensure the planning and coordination of Federal activities in marine sciences and engineering and related matters. It will identify the need for and foster studies or investigations considered appropriate, and it will review annually the Federal marine science and engineering program and budget. The Committee will assist the Office of Science and Technology in the preparation of an annual report for transmittal by the President to the Congress.

2. Scope

The Committee will be concerned with Federal scientific and engineering initiatives and programs relating to the marine environment.

3. Organization

a. Chairmanship.—The Committee will be chaired during the first two years of its existence by the Administrator of the National Oceanic and Atmospheric Administration. After the two-year period, the location of the Chairmanship will be reconsidered. Responsibility for the conduct of the work of the Committee will rest with the Chairman.

b. Meetings.—The Committee will determine its schedule of meetings as required. The Committee will also meet at the call of the Chairman. The Chairman will call meetings at the request of a Committee member or members.

c. Membership.—Each Federal agency with a program in the marine area will have membership on the Committee (generally the membership will consist of the same agencies that participated in the National Council on Marine Resources and Engineering Development).

d. Subcommittees.—The Committee may form subcommittees or task groups, usually ad hoc in nature, for the conduct of its required work.

e. Staff.—An Executive Secretary will be provided by the National Oceanic and Atmospheric Administration.

INTERAGENCY COMMITTEE ON MARINE SCIENCE AND ENGINEERING

Dr. Robert M. White, Administrator, National Oceanic and Atmospheric Administration, Department of Commerce (Chairman)

Commerce	Mr. David H. Wallace Associate Administrator for Marine Resources, NOAA
Corps of Engineers	Maj. Gen. J. W. Morris Director of Civil Works
Navy	Dr. Robert A. Frosch Assistant Secretary of the Navy for Research and Development
Health, Education, and Welfare	Mr. Richard Green Chief Engineer, U.S. Public Health Service
Interior	Dr. W. T. Pecora Under Secretary of the Interior
State	Amb. Donald L. McKernan Coordinator of Ocean Affairs and Special Assistant to the Secretary
Transportation	Adm. Chester R. Bender Commandant, U.S. Coast Guard
Atomic Energy Commission	Dr. Spofford G. English Assistant General Manager for Research and Development
Environmental Protection Agency	Dr. Stanley M. Greenfield Assistant Administrator for Research and Monitoring
National Aeronautics and Space Administration.	Mr. Leonard Jaffe Deputy Associate Administrator for Applications
National Science Foundation	Dr. Thomas B. Owen Assistant Director for National and International Programs
Smithsonian Institution	Dr. David Challinor Assistant Secretary (Science)

Mr. Steven N. Anastasion, Executive Secretary

APPENDIX E—BREADTH OF TERRITORIAL SEAS AND FISHING JURISDICTIONS CLAIMED BY SELECTED COUNTRIES

Country	Territorial sea	Fishing limit	Other
	(nautical miles)	(nautical miles)	
Albania	12	12	
Algeria	12	12	
Argentina	200	200	Permits overflight and navigation. Licensing of foreign fishing vessels from 12 to 200 n. mi.
Australia	3	12	
Belgium	3	[1] 3	
Brazil	200	200	
Bulgaria	12	12	
Burma	12	12	
Cambodia	12	12	
Cameroon	18	([2])	
Canada	12	12	
Ceylon	12	12	
Chile	3	200	
China, People's Republic of.	12	12	
China, Republic of	3	3	
Colombia	12	12	
Costa Rica	12	200	"Specialized competence" over living resources to 200 n. mi.
Cuba	3	3	
Cyprus	12	12	
Dahomey	12	12	Subsoil of area stretching 100 miles from the low-tide level or first obstacle of navigation.
Denmark	3	[1] 12	
Dominican Republic	6	12	
Ecuador	200	200	
Egypt	12	12	
El Salvador	200	200	
Ethiopia	12	12	
Federal Republic of Germany.	3	[1] 3	
Finland	4	4	
France	12	[1] 12	
Gabon	30	30	
Gambia	50	50	
Ghana	12	12	
Greece	6	6	
Guatemala	12	12	
Guinea	130	130	
Guyana	3	3	

See footnotes at end of table.

APPENDIX E—BREADTH OF TERRITORIAL SEAS AND FISHING JURISDICTIONS CLAIMED BY SELECTED COUNTRIES—Continued

Country	Territorial sea (nautical miles)	Fishing limit (nautical miles)	Other
Haiti	6	6	
Honduras	12	12	
Iceland	4	12	
India	12	12	Plus right to establish 100-mile conservation zone.
Indonesia	12	12	Archipelago concept baselines.
Iran	12	12	
Iraq	12	12	
Ireland	3	[1] 12	
Israel	6	6	
Italy	6	[1] 12	
Ivory Coast	6	12	
Jamaica	12	12	
Japan	3	3	
Jordan	3	3	
Kenya	12	12	
Korea, Republic of	3	20–200	
Kuwait	12	12	
Lebanon		6	
Liberia	12	12	
Libya	12	12	
Malaysia	12	12	
Maldives	[3] 3–55	[3] 100	Rectangular block defined by latitude and longitude.
Malta	6	12	
Mauritania	12	12	
Mauritius	12	12	
Mexico	12	12	
Morocco	12	12	Exception—6-mile zones for Strait of Gibraltar.
Netherlands	3	[1] 12	
New Zealand	3	12	
Nicaragua	3	200	Continental Shelf, including sovereignty over superjacent waters.
Nigeria	30	30	
Norway	4	12	
Pakistan	12	12	Plus right to establish 100-mile conservation zones.
Panama	200	200	Continental Shelf, including sovereignty over superjacent waters.
Peru	200	200	Sole jurisdiction over the area of the sea, the subsoil, and seabed adjacent to coastlines, including superjacent waters.

See footnotes at end of table.

APPENDIX E—BREADTH OF TERRITORIAL SEAS AND FISHING JURISDICTIONS CLAIMED BY SELECTED COUNTRIES—Continued

Country	Territorial sea (nautical miles)	Fishing limit (nautical miles)	Other
Philippines			Archipelago concept baselines. Waters between these baselines and the limits described in the Treaty of Paris, Dec. 10, 1898, the United States-Spain Treaty of Nov. 7, 1900, and United States-United Kingdom Treaty of Jan. 2, 1930, are claimed as territorial sea.
Poland	3	12	
Portugal		[1] 12	
Romania	12	12	
Saudi Arabia	12	12	
Senegal	12	18	Proposed to extend fishing jurisdiction 110 n. mi. beyond territorial sea.
Sierra Leone	200	200	
Singapore	3	3	
Somali Republic	12	12	
South Africa	6	12	
Spain	6	[1] 12	
Sudan	12	12	
Sweden	4	[1] 12	
Syria	12	12	
Tanzania	12	12	
Thailand	12	12	
Togo	12	12	
Trinidad and Tobago	12	12	
Tunisia	6	12	
Turkey	6	12	12 n. mi. in Black Sea as a matter of reciprocity.
Ukrainian S.S.R.	12	12	
U.S.S.R.	12	12	
United Kingdom	3	[1] 12	
United States of America	3	12	
Uruguay	200	200	Licensing required between 12 and 200 n. mi. Presidential Decree of Aug. 26, 1971, establishing detailed regulations for foreign fishermen in the 12- to 200-n. mi. zone.

See footnotes at end of table.

APPENDIX E—BREADTH OF TERRITORIAL SEAS AND FISHING JURISDICTIONS CLAIMED BY SELECTED COUNTRIES—Continued

Country	Territorial sea	Fishing limit	Other
	(nautical miles)	(nautical miles)	
Venezuela	12	12	
Vietnam, Republic of	3	(4)	Extension to 12 and 30 n. mi., respectively, under consideration.
Yemen (Aden)	12	12	
Yugoslavia	10	12	

[1] Parties to the European Fisheries Convention which provides for the right to establish 3-mile exclusive fishing zone seaward of 3-mile territorial sea, plus additional 6-mile fishing zone restricted to the Convention Nations.
[2] To be fixed by decree.
[3] Approximate.
[4] 20 kilometers (10.8 n. mi.).

Source: "International Boundary Study," series A, "Limits in the Seas, National Claims to Maritime Jurisdictions," *Publication No. 36*, Jan. 3, 1972 (with corrections to March 1972), issued by the Geographer, Department of State.

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